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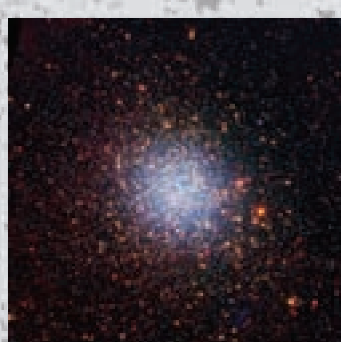
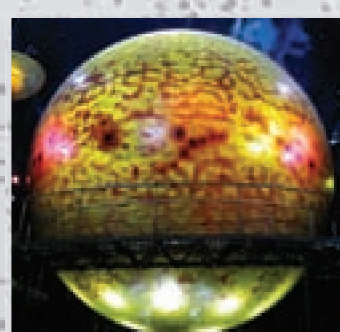
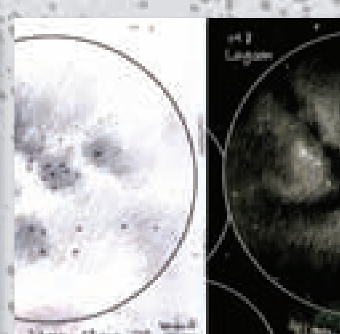

PROMOTING ASTRONOMY IN CANADA

December / décembre 2010

Journal

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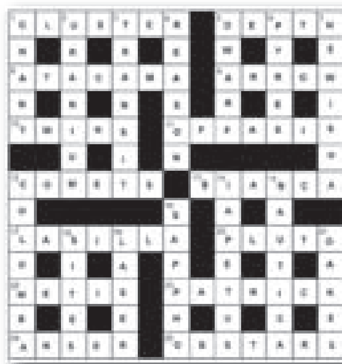

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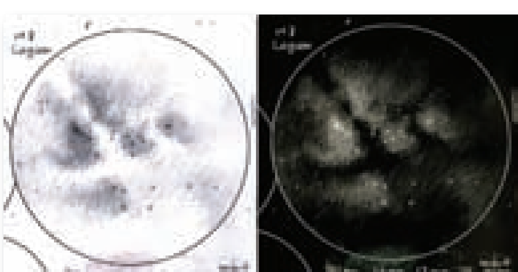

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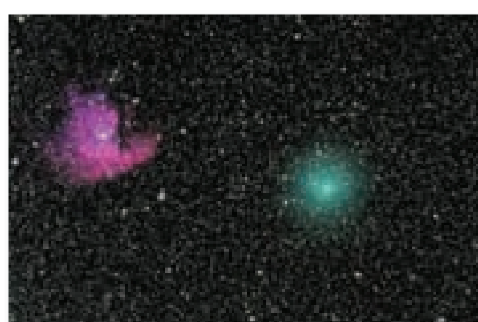
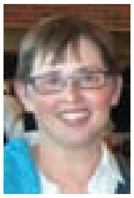


On the Cover: Hartley was the comet of the year for 2010, and while it was reluctant to grow a tail, at least managed to stray into some classy neighbourhoods. One of these is shown in this image from Winnipeg's Kevin Black, showing Comet Hartley with the PacMan Nebula. The fast movement of Hartley meant exposures had to be short. This one is a four-minute exposure taken at midnight on October 2-3 using a Canon 20Da through an 80-mm refractor.



President's Corner

by Mary Lou Whitehorne, President, RASC

Every culture has its own interpretation of the stars and the skies. There are rich troves of sky lore all around the globe. We have only to look on our own bookshelves to know that we, as a species, are storytellers. So, let me tell a story!

Once upon a time, in a fair and kindly country called Canada, there was an organization of astronomers called The Royal Astronomical Society of Canada (RASC). Theirs was an old and noble learned society of astronomers, with a long, vibrant history and an international reputation for quality, accuracy, and integrity about all of their good works.

These astronomers were storytellers, too. They told many stories of different kinds in their own storybooks. One of their storybooks is called the *Observer's Handbook*, and after 100 years, it is still a best seller. It is filled with star stories. Some of the stories are narratives and others are tabular, graphical, or numerical. But, for astronomers who know the language, these stories tell us a great deal about the stars in the sky.

But, there is another storybook from the RASC. It is called the *Journal*, or *JRASC* for short. This storybook is a periodical and is published six times each year. *JRASC* has been around for 100 years too! That's pretty amazing!

Journal

The *Journal* is a bi-monthly publication of The Royal Astronomical Society of Canada and is devoted to the advancement of astronomy and allied sciences. It contains articles on Canadian astronomers and current activities of the RASC and its Centres, research and review papers by professional and amateur astronomers, and articles of a historical, biographical, or educational nature of general interest to the astronomical community. All contributions are welcome, but the editors reserve the right to edit material prior to publication. Research papers are reviewed prior to publication, and professional astronomers with institutional affiliations are asked to pay publication charges of $100 per page. Such charges are waived for RASC members who do not have access to professional funds as well as for solicited articles. Manuscripts and other submitted material may be in English or French, and should be sent to the Editor-in-Chief.

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The *Journal* is printed on recycled stock.

Have you read the *Journal* lately? ***Your*** *Journal*. It's full of interesting star stories that you will enjoy. It used to be a peer-reviewed academic publication filled with research papers that appealed mostly to professional astronomers. Now it is focused on amateur astronomers who want to learn more about astronomy, the Universe, and how our favourite science works. It has a much broader spectrum of coverage, with popular articles, interviews, regular columns, reviews, research papers, and scholarly articles on a variety of subjects, as well as Society news and astro-images. There's no fluff (well, maybe except for this column!) and lots of solid astronomy to sink your teeth into, be inspired about, and to learn from. How can any self-respecting RASCal resist?

Every two months, the *Journal*'s Editor and team of 30 RASC volunteers work hard to bring you a mix of contributors and content that is designed to appeal to the full breadth and depth of interests of RASC members.

The *Journal* remains Canada's only astronomical journal of record. It is a publication of which we can be justly proud. So go ahead. Open the *Journal*, browse through its rich assortment of content. There's something for everyone in its pages. This is no ordinary astronomy magazine. It's ***our*** *Journal*. It is written by us, for us. It's the story of our Society.

And, the RASC astronomers opened their *Journals*, and read of its pages, and they all lived happily ever after!

News Notes/ *En manchettes*

Compiled by Andrew I. Oakes (copernicus1543@gmail.com)

Spacecraft "Dawn" heads for Venus

A Japanese unmanned spacecraft, *Akatsuki*, is on its way to explore the planet Venus. It is scheduled to conduct research for two or more years after it reaches Venus in December this year.

Launched on 2010 May 20, the spacecraft was formerly known as the *Venus Climate Orbiter (VCO*) and *Planet-C*. *Akatsuki* means "dawn."

The craft's scientific payload consists of an ultraviolet imager (UVI), a longwave infrared camera (LIR), a 1-μm camera (IR1), a 2-μm camera (IR2), and a radio science (RS) experiment. Planned investigations include surface imaging, experiments designed to confirm the presence of lightning, and determination of whether volcanism occurs on the surface.

The spacecraft features two solar arrays, each with an area of 1.4 square metres and designed to provide over 1200 watts of power while in orbit around Venus.

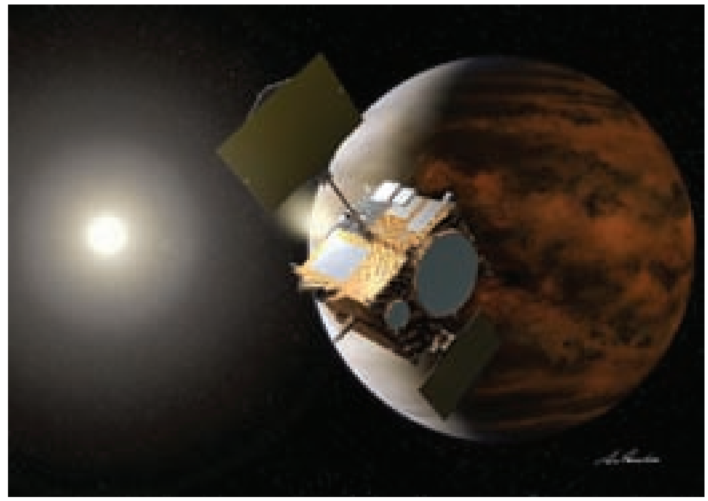

Figure 1 — An artist's impression of *Akatsuki* approaching Venus. Image by Akihiro Ikeshita, courtesy JAXA

Decadal Success of Another Venusian Spacecraft

Meanwhile, as *Akatsuki* sped on its way to Venus, the European Space Agency's *Venus Express* continued to gather scientific information about the planet, more than nine years after going into orbit. The spacecraft was built around the design of *Mars Express*, making it quicker and cheaper to develop. *Venus Express* was launched on 2005 November 9 on a Soyuz-Fregat rocket from Baikonur, Kazakhstan. It entered orbit around Venus on 2006 April 11 and has been operating successfully ever since. At the 142 million-km distance to Venus, round-trip travel time for communications signals takes some 473 seconds.

The satellite was optimized for studying the atmosphere of Venus, from the surface to the ionosphere. Its extended mission is scheduled to end 2012 December 31.

The spacecraft has recorded a number of firsts in the study of Venus:

The Royal Astronomical Society of Canada is dedicated to the advancement of astronomy and its related sciences; the *Journal* espouses the scientific method, and supports dissemination of information, discoveries, and theories based on that well-tested method.

- First global monitoring of composition of the lower atmosphere in near-infrared transparency "windows";
- First coherent study of atmospheric temperature and dynamics at different levels of atmosphere, from surface up to ~200 km;
- First measurements from orbit of global surface-temperature distribution;
- First study of middle- and upper-atmosphere dynamics from oxygen (atomic and molecular), and nitrogen-oxide emissions;
- First measurements of non-thermal atmospheric escape;
- First coherent observations of Venus in the spectral range from ultraviolet to thermal infrared;
- First application of solar/stellar occultation technique at Venus, a technique to study the characteristics of an atmosphere by monitoring how light is absorbed and fades away as a star is occulted at the limb;
- First use of 3-D ion-mass analyzer, high-energy resolution electron spectrometer, and energetic neutral-atom imager; and
- First sounding of Venusian top-side ionospheric structure.

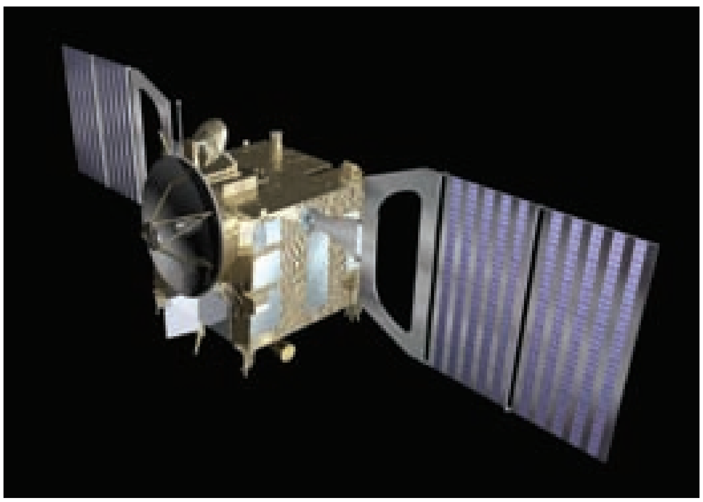

Figure 2 — The *MESSENGER* spacecraft. Image: ESA

Primitive Earth Mantle Found

The National Science Foundation (NSF), an independent U.S. federal agency that supports fundamental research and education across all fields of science and engineering, reports that a team of its co-funded researchers has found a primitive-Earth mantle reservoir on Baffin Island in the Canadian arctic. The Earth's mantle is a rocky, solid shell that lies between the Earth's crust and the outer core. It makes up about 84 percent of the Earth's volume. The mantle is made up of many distinct portions or reservoirs that have different chemical compositions.

Scientists are aware that planet Earth is slightly older than 4.5 billion years but had not yet found a piece of Earth's primitive mantle. By studying lava samples, the collaborating scientists found that the sample from Baffin Island dates the mantle reservoir to between 4.45 and 4.55 billion years old. This date is only slightly younger than the age of the Earth.

Until recently, researchers generally thought that Earth (and the other rocky planets of the Solar System) was chondritic, meaning that the mantle's chemistry was believed to be similar to that of chondrites, some of the oldest, most primitive objects in the Solar System.

However, this study, published in the 2010 August 12 issue of the journal *Nature*, challenges the idea that Earth has a chondritic primitive mantle. It suggests the possibility that, as the early Earth went through a differentiation event, its crust was extracted from the early mantle and is now hidden in the deep Earth.

When the researchers (Jackson et al. 2010, *Nature*, vol. 466, pp 853-856 Letter) studied the composition of the lava found at Baffin Island, they discovered that the sample had isotopic ratios of three chemical elements – helium, lead, and the new non-chronditic neodymium ratio – consistent with a differentiation event.

In a chondritic model of Earth, the primitive mantle would have certain isotope ratios of the chemical elements of helium, lead, and neodymium. However, five years ago, a team at the Carnegie Institute of Washington reported that the ratio of neodymium on Earth was higher than what would be expected if the Earth were indeed chondritic. That finding changed the neodymium ratio expected in the primitive mantle.

The Baffin Island research was supported by the NSF and the Carnegie Institute of Washington.

Gazetteer Naming Categories

With a number of planetary survey missions now in various stages of discovery – either orbiting planets or on their way through our Solar System to do so – any new ground-level features discovered will follow a specific naming convention to which the astronomical community worldwide will automatically adhere.

The *Gazetteer of Planetary Nomenclature*, developed by the International Astronomical Union's Working Group for Planetary System Nomenclature, provides clear direction to scientists for naming previously unidentified features on planets and their satellites that fall within general categories.

What follow are examples of three Solar System bodies where scientific exploratory work is either in progress or awaiting the arrival of unmanned space craft to begin scientific programs.

The planets Mercury and Venus, and the Saturnian moon, Titan, follow the naming conventions as outlined in the respective tables on the next page.

Planet: Mercury	
Craters	Deceased artists, musicians, painters, and authors who have made outstanding or fundamental contributions to their field and have been recognized as art historically significant figures for more than 50 years
Dorsa	Deceased scientists who have contributed to the study of Mercury
Fossae	Significant works of architecture
Montes	Word for "hot" in various languages
Planitiae	Names for Mercury (either the planet or the god) in various languages
Rupēs	Ships of discovery or scientific expeditions
Valles	Radio telescope facilities

Planet: Venus	
Astra	Goddesses, miscellaneous
Chasmata	Goddesses of hunt; moon goddesses
Colles	Sea goddesses
Coronae	Fertility and Earth goddesses
Craters	Craters >20 km: Deceased women who have made outstanding or fundamental contributions to their field; :craters < 20 km: common female first names
Dorsa	Sky goddesses
Farra	Water goddesses
Fluctūs	Goddesses, miscellaneous
Fossae	Goddesses of war
Labyrinthi	Goddesses, miscellaneous
Lineae	Goddesses of war
Montes	Goddesses, miscellaneous (also one physicist)
Paterae	Famous women
Planitiae	Mythological heroines
Plana	Goddesses of prosperity
Regiones	Giantesses and Titanesses (also two Greek alphanumeric)
Rupēs	Goddesses of hearth and home
Tesserae	Goddesses of fate and fortune
Terrae	Goddesses of love
Tholi	Goddesses, miscellaneous
Undae	Desert goddesses
Valles	Word for planet Venus in various world languages (400 km and longer); River goddesses (less than 400 km in length)

Satellite: Titan	
Albedo features	Sacred or enchanted places, paradise, or celestial realms from legends, myths, stories, and poems of cultures from around the world
Craters, ringed features	Gods and goddesses of wisdom
Facula, faculae	Facula: Names of islands on Earth that are not politically independent; Faculae: Names of archipelagos
Fluctūs	Gods and goddesses of beauty
Flumina	Names of mythical or imaginary rivers
Insulae	Names of islands from legends and myths
Lacūs	Lakes on Earth, preferably with a shape similar to the lacus on Titan
Maria	Sea creatures from myth and literature
Other features: (maculae, regions, arcūs)	Deities of happiness, peace, and harmony from world cultures
Planitiae, labyrinthi	Names of planets from the *Dune* series of science fiction novels by American author Frank Herbert (1920 -1986)
Undae	Gods and goddesses of wind
Virgae	Gods and goddesses of rain

The *Gazetteer of Planetary Nomenclature* also provides naming conventions for asteroids whose surface features are known, as well as other Solar System planets and their satellites, where appropriate.

In a recent development earlier this year, the International Astronomical Union approved names for ten impact craters on the planet Mercury. The newly named craters - see the partial global mosaic of Mercury's surface for locations - include:

- Bek, for Bek, an Egyptian sculptor (active *c.* 1340 BC);
- Copland, for Aaron Copland, an American composer (concert and film music) and pianist (1900-1990);
- Debussy, for Claude Debussy, a French composer (1862-1918);
- Dominici, for (Suor) Maria de Dominici, a Maltese sculptor and painter (1645-1703);
- Firdousi, for Abulkasim Firdousi, a Tajik/Persian poet (*c.* 940-1020/30);
- Geddes, for Wilhelmina Geddes, an Irish stained-glass and graphic artist (1887-1955);
- Hokusai, for Katsushika Hokusai, a Japanese painter, draftsman, and printmaker (1760-1849);
- Kipling, for Rudyard Kipling, an English author (1865-1936);
- Picasso, for Pablo Picasso, a Spanish-born French painter and sculptor (1881-1973); and
- Steichen, for Edward Steichen, an American photographer, painter, and art gallery and museum curator (1879-1973).

These 10 newly named craters join 42 others named since *MESSENGER*'s first Mercury flyby in January 2008.

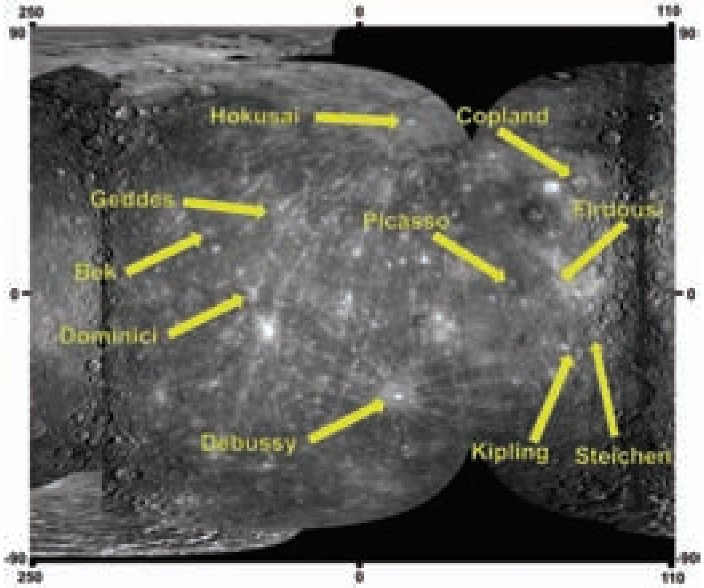

Figure 3 — A portion of a global mosaic of Mercury's surface shows the locations of the ten newly named craters. Image: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington

Life of Physicist Remembered

With the year 2010 almost at an end, *News Notes / En Manchettes* would be remissnot to note, for the record, in the closing days of the year, that the field of astronomy lost an exceptional physicist early in the calendar year with the death of Geoffrey Ronald Burbidge on 2010 January 26.

Dr. Burbidge, 84, died after a long illness in San Diego, California. He was described in one obituary as "one of the last surviving giants of the postwar era of astronomy, when big telescopes were sprouting on mountain peaks ... and peeling back the sky, revealing a universe more diverse and violent than anybody had dreamed..."

A significant juncture in his professional life occurred in 1957 with his collaboration on a scientific paper that is considered "one of the major papers of the century."

The groundbreaking research paper appeared in the journal *The Reviews of Modern Physics* and was the outcome of the collaboration between Dr. Burbidge, E. Margaret Burbidge (his wife), William Fowler of the California Institute of Technology, and Fred Hoyle of Cambridge University.

The collaboration, famously noted within the scientific community by the authors' family name initials B^2FH (pronounced "B squared F H"), resulted in an astrophysics paper titled "Synthesis of the Elements in Stars," which is now typically referred to only as *B^2FH*. The paper is credited with originating the theory of stellar nucleosynthesis.

B^2FH laid out the way that thermonuclear reactions in stars could slowly seed a Universe that was originally pure hydrogen, helium, and lithium with heavier elements like oxygen, iron, carbon, and others from which life is derived. It led to the understanding that we (and everything else) are truly all stardust stuff.

Born in 1925 in Chipping Norton, England, in the Cotswolds hills halfway between Oxford and Stratford-on-Avon, Dr. Burbidge's father was a builder and his mother was a milliner. An only child, he was the first of his family to progress beyond grammar school.

During his successful career, Dr. Burbidge was skeptical of the Big Bang theory and published a paper with four other astronomers in the journal *Nature* in 1990 listing arguments against the Big Bang. Dr. Burbidge preferred Dr. Hoyle's Steady State theory of an eternal Universe and argued in favour of a series of local "small bangs" occurring once every 20 billion years or so.

In 1967, the Burbidge husband-and-wife team produced one of the earliest surveys of quasars in their *Quasi-Stellar Objects*.

Dr. Geoffrey Burbidge served as editor-in-chief of the *Annual Review of Astronomy and Astrophysics* for 30 years, and, in 2005, Geoffrey and Margaret Burbidge were awarded the Royal Astronomical Society's gold medal, the Society's highest honour, for their contributions to astronomy for over half a century.

Figure 4 — Geoffrey Burbidge. Image: UCSD

Planet Mercury is Focus of Six Scientific Questions

NASA's literature says that of the terrestrial planets [Mercury, Venus, Earth, and Mars], Mercury is an extreme – the smallest, the densest, the one with the oldest surface, the one with the largest daily variations in surface temperature, and the least explored.

An understanding of this "end member" (closest to the Sun) among the terrestrial planets is seen as crucial to developing a better understanding of how the planets in our Solar System formed and evolved.

With this objective in mind, NASA's *MESSENGER* mission, spacecraft, and science instruments are focused on answering six key outstanding questions that will allow scientists to understand Mercury as a planet.

The six questions are:

- Why is Mercury so dense?
- What is the geologic history of Mercury?
- What is the nature of Mercury's magnetic field?
- What is the structure of Mercury's core?
- What are the unusual materials at Mercury's poles?
- What volatiles are important at Mercury?

MESSENGER [**ME**rcury **S**urface, **S**pace **EN**vironment, **GE**ochemistry, and **R**anging], was launched on 2004 August 3. If all proceeds as planned, Mercury-orbit insertion of the spacecraft will occur on 2011 March 19, with *MESSENGER* becoming the first spacecraft to orbit the planet.

To date, *MESSENGER* has followed a path through the inner Solar System, which has included one flyby of Earth, two flybys of Venus, and three flybys of Mercury.

These flyby events occurred on the following dates and distances from their respective planets:

- Earth Flyby - August 2, 2005 - 2,348 km altitude;
- Venus Flyby 1 - October 24, 2006 - 2,987 km altitude;
- Venus Flyby 2 - June 5, 2007 - 338 km altitude;
- Mercury Flyby 1 - January 14, 2008 - 200 km altitude;
- Mercury Flyby 2 - October 6, 2008 - 200 km altitude; and
- Mercury Flyby 3 - September 29, 2009 - 228 km altitude.

As of launch, *MESSENGER*'s journey has returned the first new spacecraft data from Mercury since the Mariner 10 mission over 30 years ago.

Earlier this year, *MESSENGER*'s Wide Angle Camera (WAC) of the Mercury Dual Imaging System (MDIS) WAC Filter: 2 (clear filter), captured an intriguing photograph of the Earth and its Moon. It was taken at a distance of 183 million kilometres from the Earth (for comparison, the average separation between the Earth and the Sun is about 150 million kilometres). *MESSENGER* acquired the image as part of its campaign to search for vulcanoids, small rocky objects that are suspected to exist in orbits between Mercury and the Sun.

No vulcanoids have yet been detected; however, *MESSENGER* is in a unique position to look for smaller and fainter vulcanoids than has ever before been possible.

Andrew I. Oakes is a long-time Unattached Member of RASC who lives in Courtice, Ontario.

Research papers
Articles de researche

The Radial Velocity, Space Motion, and Galactic Orbit of GJ 754

K.A. Innanen[1] and C. Flynn[2]

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[2]Department of Physics & Astronomy, Turku University, Tuorla Observatory, Pükkiö, Finland

Abstract: The radial velocity of the nearby southern dwarf GJ 754 has been measured. From this value, together with its known magnitude, proper motion, and distance, its space-velocity components relative to the Sun are computed. From an adopted galactic gravitational potential, we provide an indication of its galactic orbit.

Résumé: La vitesse radiale de l'étoile naine GJ 754 à proximité sud a été mesurée. Depuis cette valeur, et en tenant compte de sa magnitude connue, de son mouvement propre et de sa distance, les composantes de sa vitesse dans l'espace relative au soleil ont été calculées. Selon le potentiel galactique gravitationel que nous avons adopté, nous fournissons une indication de son orbite galactique.

Key words. GJ 754 – radial velocity – space motion - galactic orbit

1. Introduction

GJ 754 is a southern M4.5 dwarf star, belonging to the company of the nearest hundred stars (Batten 2009), but for which there was no radial velocity in Batten's list. Earlier, rather less accurate radial velocities for this star can be found in Gliese & Jahreiss (1969), Rodgers & Eggen, (1974), and in Hawley *et al.* (1996). Thus we were motivated to acquire this quantity, from which we could investigate its galactic orbit. In this note, we provide a more accurate radial velocity, as well as the spectrum of this star. Combined with its known magnitude, distance, parallax, and proper motion, its space velocity relative to the Sun has been computed. From an adopted galactic gravitational potential, we find that its orbit is not typical of solar neighbourhood stars, but rather an example of the thick-disk population.

2. Observations

The known data set for this star is as follows: position (2000): RA $19^h\ 21^m$; Dec -45° 33′; parallax 169 mas, (Jao *et al.* 2005); spectral type M4.5; proper motion μ_α = 792 msec/yr; μ_δ = -3008 marcsec/yr; V = 12.23; Mv = 13.44. A good quality spectrum of GJ 754 was obtained by M.S. Bessel and S. Murphy in early March, 2009 using the 2.3-m telescope at Siding Spring.

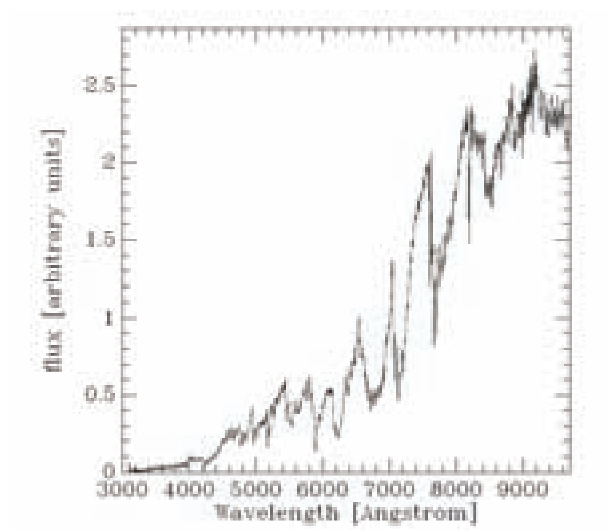

Figure 1 — Spectrum of GJ 754

3. Data Reductions and Analysis

The observed radial velocity of GJ 754 is 1± (1) km/sec. The space-velocity components (U, V, W) relative to the Sun were computed using two independent programs; they are (27, -72, -41) km/sec. U is positive toward the galactic centre, V is positive in the direction of galactic rotation, and W is positive in the direction of the North Galactic Pole. We have adopted the solar peculiar motion components U = 11.1, V = 12.2, and W = 7.3 km/sec (Schönrich *et al.* 2010).

4. The Galactic Potential

We have used a galactic potential generically similar to the one used in Innanen (2007). Unhappily, the values for $R_\odot$ (the distance of the Sun from the galactic centre) and $V_\odot$ (the velocity of the Sun in its galactic orbit) continue their historical uncertainties, with the latter quantity showing a recent upward trend (Reid *et al.* 2009; McMillan & Binney 2010; Schönrich *et al.* 2010). The recent values for $V_\odot$ are in good accord with the value of 235 km/sec proposed by Carlberg and Innanen (1987), although this latter result was based on weak statistics. Accordingly, we have adopted $R_\odot$ = 8.2 kpc, and $V_\odot$ = 240 km/sec. The local galactic density ($\rho_\odot = 0.11 M_\odot/\mathrm{pc}^3$ (Holmberg & Flynn 2000). The resulting galactic orbit of GJ 754 is shown in Figure 2 in the standard rotating frame. We note that this orbit has a moderate quasi-eccentricity of 0.25 and a z-amplitude of ± (0.6) kpc. Evidently this orbit is characteristic of a thick-disk population. Happily, this conclusion is not strongly dependent on our galaxy model, unless there might exist an interior bar or a spiral arm resonating with this star. Should the radial velocity be as high as 6.7 km/sec (Forveille 2010), then the space-motion components (U,V,W) become (21.5, -73.2, -43) km/sec, but we find that the space-motion components used above do not change a great deal, and our galactic orbit is not sensitive to the radial velocity at ± (5) km/sec.

5. Discussion

We have measured the radial velocity of GJ 754 to be 1±(1) km/sec relative to the Sun. Its spectrum is shown in Figure 1. On this basis and its known distance, magnitude, and proper motion, its space motion has been computed. A conventional axisymmetric galactic potential suggests that its moderately eccentric orbit and maximum distance from the galactic plane are not like typical orbits in the solar neighbourhood, but rather characteristics of a thick-disk population. Naturally, that conclusion will change if other resonances are at work, such as from an internal bar or if our observation is not accurate (Forveille 2010).

6. Acknowledgments

KI is grateful to Chris Flynn for travel support and to Tuorla Observatory for accommodation assistance, and where discussions of this work were initiated in 2008. He also thanks Dr. Kris Innanen for manuscript preparation assistance. The authors are most grateful to Drs. M.S. Bessell and S. Murphy of the Mt. Stromlo Observatory for acquiring the spectrum. We are also grateful to Dr. T. Forveile for alerting us to additional observations.

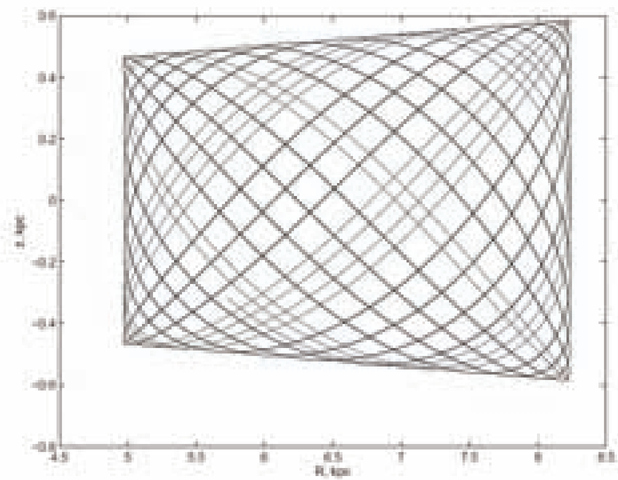

Figure 2: Galactic orbit of GJ 754

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Feature Articles/
Articles de Fond

À l'assaut des trous noirs, phénix de l'espace...

par Gerardina Pasquariello

Abstract: This article is an exposé on the progress of studies on black holes through the centuries, with a particular focus on Canadian discoveries in this field. While based on scientific fact, the text is written eloquently with a creative spirit, to provide a better grasp of this complex topic.

Résumé: Cet article porte sur le progrès des études liées aux trous noirs, à travers les siècles, et met l'accent sur la promotion des découvertes canadiennes dans ce domaine. Reposant sur des faits scientifiques, le langage éloquent du texte et le style élégant facilitent la compréhension de ce sujet complexe. Ceci se veut un ouvrage de vulgarisation scientifique.

Depuis la nuit des temps, l'homme a été subjugué par le panorama grandiose de la voûte astrale, protagoniste de maints cultes, mythes et légendes. Divinités, amants éplorés éternels, gardiens du ciel et autres êtres célestes se sont disputés la place d'honneur dans la vastitude sidérale. Si aujourd'hui, certaines croyances se sont dissipées avec la progression des découvertes scientifiques, plusieurs autres mystères et énigmes demeurent aussi nébuleux que les poussières interstellaires laissées par le Big Bang.

Examinons les trous noirs, ces avatars de l'espace...

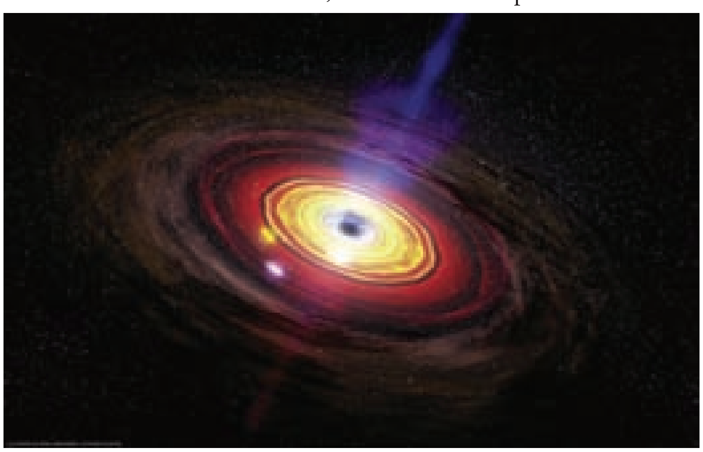

Figure 1 — Représentation d'un trou noir. Image : NASA/Dana Berry, Skyworks Digital

Dans notre quête cosmique, l'existence des trous noirs a captivé non seulement l'attention d'astrophysiciens et de théoriciens, mais aussi l'esprit créatif des férus de la cinématographie (*La guerre des étoiles, The Black Hole, Star Trek, Stargate, Contact*...), de la littérature (*Eureka d'Edgar Allan Poe*), de la musique (*Black Hole Sun de Soundgarden*) et de l'art. Selon certaines hypothèses, les trous noirs nous permettraient de voyager dans l'espace, dans le temps et vers d'autres univers ou mondes parallèles. Ils seraient une sorte de portail multidimensionnel.

Mais qu'est ce qu'un trou noir réellement?

Avant d'élaborer davantage sur ce fascinant concept, il importe de comprendre les lois définissant la déchéance d'une étoile.

Comme tous les êtres vivants, une étoile n'est, hélas, point immortelle. Selon sa masse d'origine, l'étoile peut s'éteindre de 3 façons.

En premier lieu, pour une étoile dont la masse du noyau est inférieure à 1.4 Ms (masse solaire), lorsque son hydrogène se tarit et que l'hélium s'amoncelle en son centre, la masse et la chaleur du noyau se multiplient. L'étoile devient alors littéralement une « naine blanche », dense et compacte. À l'approche de sa fin imminente, l'étoile émet des jets de lumière discontinus. Étant donné sa masse moins importante, la pression d'électrons dégénérés la maintiendra en état d'équilibre éternel. La gravité est endiguée et aucune réaction thermonucléaire ne se produit. En se refroidissant graduellement, au cours des millénaires, l'étoile se cristallise en carbone et en hélium. Elle se transforme alors de naine blanche à naine dite noire, un astre dénué de luminosité. Tel est le destin de la majorité des étoiles ayant épuisé leurs ressources nucléaires et, semble-t-il, tel sera le sort du Soleil d'ici quelques milliards d'années.

En deuxième abord, pour une étoile au terme de sa vie, si la masse du noyau est comprise entre 1.4 et 3.4 Ms, la pression de dégénérescence est insuffisante pour supporter l'effondrement gravitationnel. À l'antithèse des naines blanches, les électrons cèdent prise. Sous l'effet de l'intense pression, ils s'infiltrent au cœur-même des atomes et s'annulent au contact des protons. Ce faisant, ils se transforment en neutrons; d'où le surnom « étoile à neutron » ou pulsar.

Le troisième scénario survient lorsque la masse du noyau outrepasse 3.4 Ms. C'est l'énigmatique phénomène du trou noir.

Par définition, un trou noir est un amas de particules si denses (jusqu'à des milliards de fois plus denses que tout autre corps astral), que sa force gravitationnelle ne permet à aucune substance ou rayon de s'en échapper; une prison cosmique quoi! Ces particules sont, en fait, les vestiges de l'anéantissement d'une étoile massive éclatant en supernovae. À court de combustible nucléaire, cette étoile rend l'âme. De fait, elle implose en quelque sorte ou plutôt, elle s'effondre sur elle-même. Cet effondrement gravitationnel provoque une décomposition de ses atomes et une fusion des protons et électrons en neutrons, amplifiant la densité de manière phénoménale. Si la masse du résidu atteint trois fois la masse du Soleil, la *vitesse de libération*

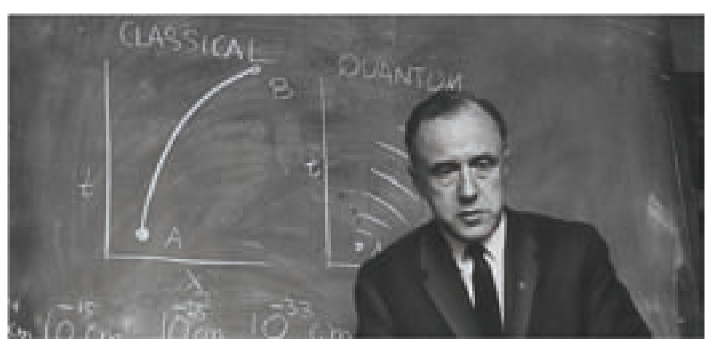

Figure 2 — John Wheeler. Image: New York Times/fichier 1967

(vitesse permettant d'échapper au champ gravitationnel d'un astre) rejoint la vitesse de la lumière. Conséquemment, l'attraction de cette étoile devient si soutenue que rien, ni même la lumière, ne peut s'en esquiver. Le résidu d'étoile se transforme ainsi en un trou noir, indiscernable à l'œil humain.

Ce n'est que vers 1967 que le terme « trou noir » éclot, des études de John A. Wheeler. Il est définit comme une concentration de masse/énergie si compacte que même les photons ne peuvent se dérober à sa force gravitationnelle.

Quoique la notion n'ait été popularisée qu'en ce siècle, le concept du trou noir a été pondu il y a plus de 300 ans, avec la théorie de Newton sur **la gravitation universelle.**

La loi newtonienne stipule que : "*Tout corps matériel dans l'univers attire tout autre corps avec une force directement proportionnelle au produit de leurs masses et inversement proportionnelle au carré de leur distance*".

Figure 3 — Isaac Newton par Godfrey Kneller (1702)

Mais quel rôle la gravitation joue-t-elle dans les astres ?

La gravitation est au cœur-même du cycle de vie d'une étoile car celle-ci naît et expire avec l'effondrement gravitationnel. Une étoile prend forme dans une nébuleuse, de l'effondrement gravitationnel d'une condensation moléculaire. Suite à un événement déclencheur, par exemple l'explosion d'une géante, l'espace-temps subi une onde de choc; une onde gravitationnelle. Dès lors, les particules de gaz et de poussières commencent à s'agglutiner. Les atomes d'hydrogène se percutent et la température augmente graduellement. La pression s'amplifie et tout se met en rotation. C'est le stade de la protoétoile. Afin d'instiguer des réactions nucléaires en son centre et évoluer en étoile, la protoétoile doit posséder une masse supérieure à 0.08 Ms. Si sa masse est trop petite, elle se contractera davantage et deviendra une naine brune (étoile manquée). Toutefois, si la masse est propice, le noyau atteindra des températures atteignant des millions de degrés. Quelques millions d'années plus tard, nous assistons à la naissance d'une étoile.

Vers la fin du 18e siècle, enthousiasmés par les recherches de Newton, John Mitchell et Pierre Laplace se penchent sur l'étude des corps dont la vitesse indispensable pour esquiver leur attraction est supérieure à la vitesse de la lumière.

Ce n'est que beaucoup plus tard, avec la théorie d'Einstein sur la relativité générale, que la notion de trou noir est amplement couvée.

Cette théorie de relativité einsteinienne, vulgarisée à sa plus simple expression, implique que la gravité courbe et déforme l'espace et le temps autour d'un objet de masse. Plus la masse est concentrée, plus la courbure est prononcée. Dans l'enseignement classique, on nous apprend que nul ne peut surpasser la vitesse de la lumière. Or, c'est ici qu'entre en jeu le principe d'équivalence, l'un des éléments-clé de la théorie. D'après ce principe, la force gravitationnelle est parfaitement identique aux forces d'accélération. Donc, par exemple, lorsqu'un véhicule amorce un virage, accélère ou ralentit, son passager n'a aucune idée si les forces produites sont dues à la gravitation ou à l'accélération. Des études poussées récentes démontrent que la théorie relativiste supplante la théorie de Newton. Cependant, elle ne prouve pas fondamentalement l'existence des trous noirs car elle demeure inconciliable avec la physique quantique.

Malgré cela, cette théorie soulève tout de même un pan de voile sur l'expansion de l'Univers.

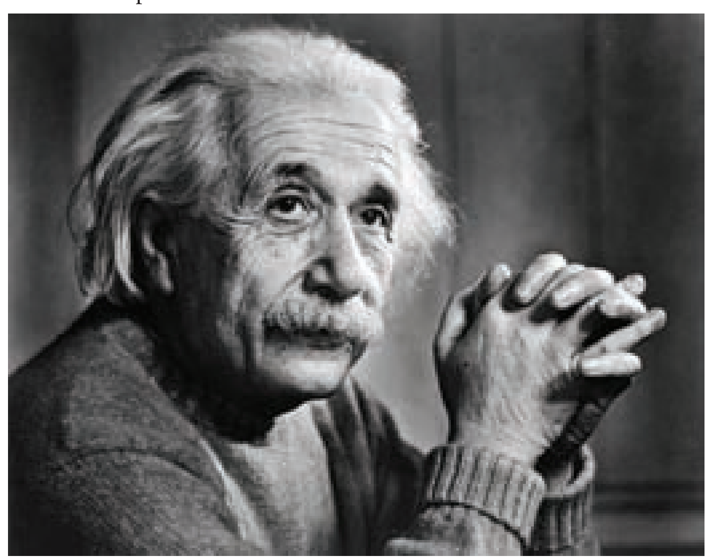

Figure 4 — Albert Einstein en 1948.

En 1916, un an après la publication de cette théorie einsteinienne, Karl Schwarzschild résout l'équation relativiste et met en place un modèle de trou noir statique, sans rotation ni charge électrique, exclusivement défini par sa masse; $R = 2GM/c^2$. Selon lui, toute matière est sujette à évoluer en trou noir s'il existe une force pouvant comprimer cette matière jusqu'à ce que son rayon atteigne une valeur déterminante.

Le trou noir serait délimité par une surface en forme de sphère, divisant l'intérieur de l'extérieur. Cette surface est communément désignée comme « l'horizon des événements » et sa taille, « le rayon de Schwarzschild » Quant à son centre, il est définit en tant que « singularité », une région dans laquelle le champ de gravité et les courbures de l'espace sont illimités.

Le trou noir de Schwarzschild est le premier et plus simple modèle élaboré.

En 1918, Heinrich Reissner et Gunnar Nordström décrivent un trou noir possédant une charge électrique et générant des jets de plasma. C'est le trou noir de Reissner-Nordström, le 2e modèle élaboré.

Figure 5 — Karl Schwarzschild

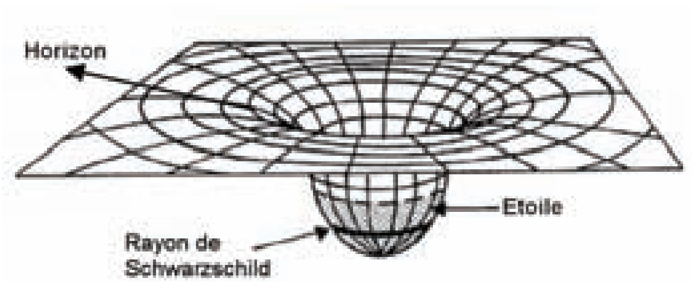

Figure 6 — Trou noir de Schwarzschild

À l'instar du modèle de Schwarzschild, la singularité et la sphère de photons sont analogues, cependant l'horizon des évènements est subdivisé en 2 parties. L'horizon extérieur est associé à la force gravitationnelle du trou noir tandis que l'horizon intérieur est rattaché à sa charge électrique. Cela présuppose que si la matière a une charge, la charge serait maintenue sous la forme d'un champ électrique se répandant autour de la singularité.

Malheureusement, le modèle Reissner-Nordström est considéré comme peu probable par les scientifiques car aucun processus actuel ne permet de créer un objet compact capable de maintenir une importante charge électrique pendant une longue période de temps.

Le 3e modèle est élaboré par Roy Kerr, vers 1963. La particularité du trou noir de Kerr réside dans son mouvement rotatif, aussi appelé moment cinétique. Tout comme le modèle Reissner-Nordström, ce dernier détient 2 horizons des événements. Toutefois, le modèle de Kerr suppose l'existence d'un horizon double en raison de la rotation du trou noir, et non de sa charge. En outre, ce tierce modèle aurait une ergosphère (région avoisinante du trou noir en rotation). Un corps n'échouerait pas nécessairement dans la singularité. Si sa force est substantielle, il peut atteindre une vitesse de libération le catapultant à l'extérieur de l'influence gravitationnelle.

Ce modèle, quoique se rapprochant davantage de la réalité physique, n'est pas plus plausible car il ne décrit point ce qui se passe pendant l'étape d'effondrement. Il ne fait que prédire une résultante finale.

À ce jour, le modèle exemplaire n'a pas encore été élaboré.

Les astrophysiciens distinguent 4 classes de trous noirs, en fonction de leur masse:

- les trous noirs stellaires
- les trous noirs supermassifs
- les trous noirs intermédiaires
- les trous noirs primordiaux

La plupart des trous noirs seraient d'origine stellaire, c'est-à-dire qu'ils proviennent de l'effondrement gravitationnel du noyau central d'une étoile massive mourante. Ces types de trous noirs ne possèdent que quelques masses solaires. C'est en 1939 que Robert Oppenheimer calcule que si un noyau stellaire s'effondre sous l'effet de sa propre force gravitationnelle, une masse de 3,2 masses solaires le transformera en trou noir.

Chaque galaxie abriterait des milliards de trous noirs stellaires.

Les trous noirs supermassifs se trouveraient au centre de chaque galaxie. Ces immenses avaleurs de matière contiendraient entre un million et un milliard de masses solaires. Il est estimé que ces derniers ne naissent pas nécessairement de l'effondrement stellaire car aucune étoile de cette masse n'existe dans notre Univers. L'hypothèse de formation de ces trous noirs supermassifs est fortement débattue, mais la plus récurrente implique que ceux-ci seraient initialement des trous noirs stellaires ayant aspiré une quantité incommensurable de matière pendant des milliards d'années.

Les trous noirs intermédiaires auraient une masse variant entre 100 et 10 000 masses solaires. Ces derniers prendraient forme dans les amas globulaires, jusqu'à présent, aucune observation n'a permis de confirmer l'existence de ceux-ci.

Figure 7 — Amas globulaire Omega du Centaure (NGC 5139) Image: NASA/JPL-Caltech/Noao/Aura/NSF

Dans l'ultime catégorie, on retrouve les trous noirs primordiaux. Ces derniers, aussi surnommés micro trous noirs ou trous noirs quantiques, se seraient formés lors du Big Bang, la matière étant soumise à des forces gravitationnelles d'une intensité inouïe. C'est micro trous noirs se caractérisent par leur plus petite taille, d'où leur surnom.

En 1975, Stephen W. Hawking, physicien théoricien et cosmologiste anglais, élabore une théorie selon laquelle un micro trou noir rayonne d'énergie et perd donc progressivement de sa masse puisque une émission de photons est égale à un rayonnement thermodynamique. Ce rayonnement thermique draine peu à peu l'énergie et la matière des trous noirs. Ainsi, plus un trou noir est petit, plus vite il se dissiperait. Il finirait par disparaître complètement, en s'évaporant, quelque temps après sa formation. Par exemple, pour un trou noir de 2 Ms, cela prendrait $1,2 \times 10^{67}$ années avant que le trou noir ne s'évapore complètement.

Hawking explore le lien entre la physique quantique et la relativité générale. Selon lui, un trou noir n'est pas totalement dépourvu de lumière. Il devrait, en fait, émettre des rayonnements aléatoires. Le rayonnement d'Hawking sème la zizanie au sein de la communauté scientifique car il chamboule la définition-même du trou noir. Un rayonnement suppose une libération de particules dans l'espace, ce qui va à l'encontre des théorèmes établis.

En principe, un trou noir est indétectable, voire invisible. Toutefois, les phénomènes cosmiques provoqués par son champ de gravitation peuvent être un signe prodromique de son existence. La force gravitationnelle du trou noir est telle qu'elle altère l'espace-temps, obnubilant lumière et matière. Ceci engendre un effet de lentille gravitationnelle, où l'on observe la brusque déviation des rayons lumineux à proximité. Ce phénomène a d'ailleurs été prédit par la théorie de relativité généralisée.

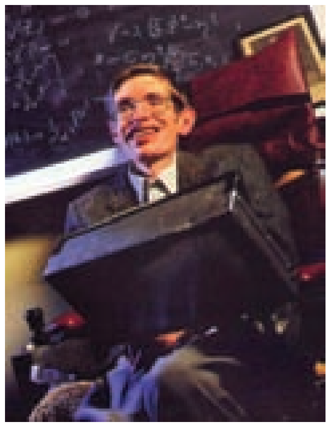

Figure 8 — Stephen W. Hawking

L'une des références les plus notoires de la lentille gravitationnelle demeure la Croix d'Einstein, dotée d'un quasar (galaxie possédant un noyau ultra lumineux) à 10 milliards d'années-lumière et d'un trou noir en son milieu. L'image que nous entrevoyons sous la forme d'une croix est décuplée par le champ de gravitation d'une galaxie 10 fois moins loin.

Figure 9 — Image recréée - basé sur www.nrumiano.free.fr

La détection d'un trou noir est aussi possible grâce au disque d'accrétion, formé de rayons gamma et de photons x.

Tel un Cyclope de l'espace, l'énorme puits de gravité du trou noir aspire et ingère goulûment toute substance environnante. Lorsque la matière est accrétée, elle atteint une très haute température, un impressionnant nombre de rayons-X sont émis et le degré de luminosité s'intensifie. Un disque d'accrétion se forme alors temporairement (tourbillon de nuages gazeux), et cette image est captée par des télescopes situés à l'extérieur de l'atmosphère terrestre.

Maintenant que nous savons comment déceler un trou noir, une question primordiale subsiste.

Que devient la matière engloutie?

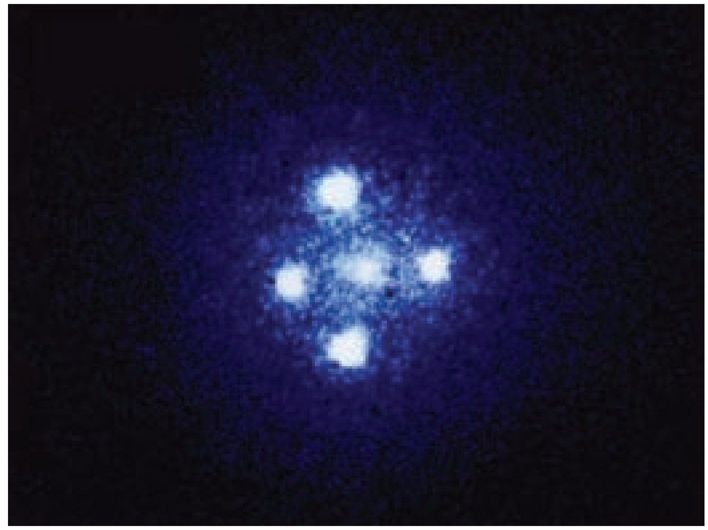

Figure 10 — Croix d'Einstein. Image: Space Telescope Science Institute/NASA

En 1967, Werner Israël de l'Université d'Alberta indique qu'une fois le trou noir formé, seuls la masse totale, la charge électrique et le moment où la matière a été aspirée peuvent le définir. Toute autre information se perd dans le néant. C'est le fameux théorème de la calvitie. À l'aide des formules mathématiques, Israël démontre que les trous noirs sont les plus simples objets de taille impressionnante à peupler l'Univers.

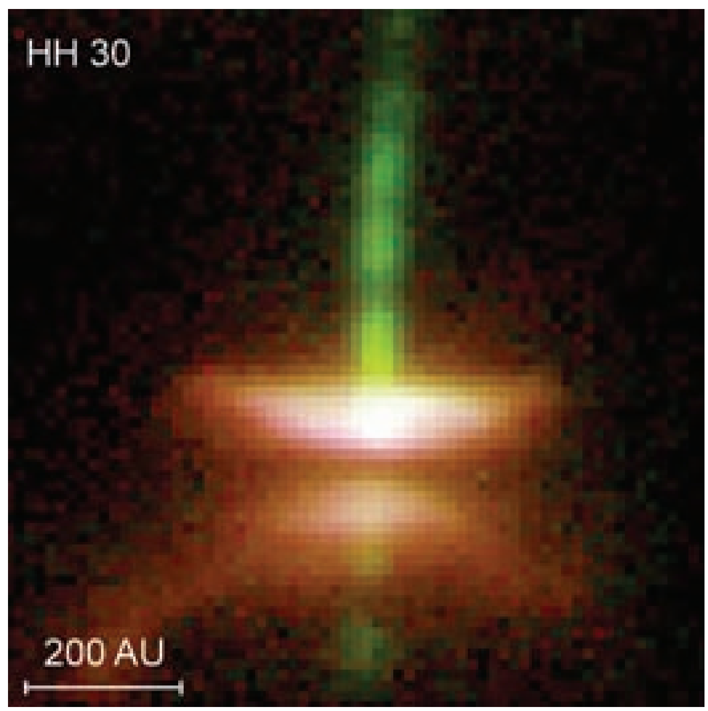

Figure 11 — Un exemple d'un disque d'accrétion et de son jet. Image: Burrows, STScI/ESA, WFPC2, NASA.

La théorie d'Israël suppose que si on tombait dans un trou noir, on ne serait pas en mesure d'envoyer des signaux à l'externe, mais on continuerait à recevoir des messages de l'intérieur. En outre, on ne survivrait sûrement pas à la gravité croissante.

Einstein, lui, croyait que la matière accrétée par un trou noir pouvait être expulsée dans le passé ou le futur, à des milliards d'années. C'est ce que l'on appelle communément le principe du trou de ver ou le pont Einstein-Rosen, joignant les horizons de 2 univers. Ce trou de ver permettrait, entre autres, de voyager plus rapidement que la lumière. Le phénomène créerait des tunnels spatio-temporels vers d'autres univers et vers d'autres périodes dans le temps.

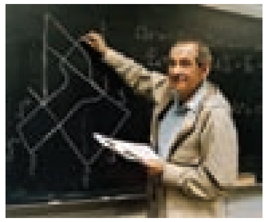

Figure 12 — Werner Israël.

Tel que survolé brièvement précédemment, plusieurs genres de trous de ver sont envisagés à l'heure actuelle:

- Le trou de ver de Schwarzschild, qui serait totalement infranchissable.
- Le trou de ver de Reissner-Nordström ou Kerr-Newmann, franchissable mais dans une seule direction.
- Le trou de ver de Lorentz à masse négative, franchissable dans les deux directions.

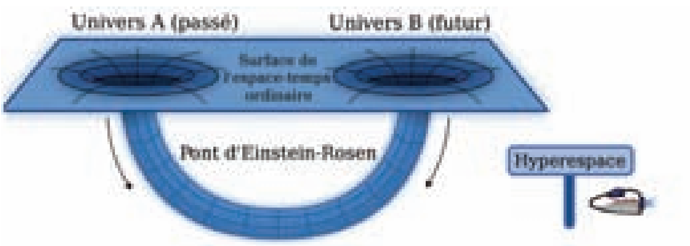

Figure 13 — Schéma du trou de ver de Lorentz. Source: fr.wikipedia.org

La porte de sortie du trou de ver est considérée comme un trou blanc. Matière et lumière pénétreraient dans le trou de ver, pour en ressortir, possiblement quelques milliers d'années plus tard ou plus tôt, jaillissant sous forme de « lumière blanche », d'une puissante intensité gravitationnelle.

Mais pourrait-on réellement voyager dans le temps?

Étant entièrement gouvernés par les lois de la mécanique quantique, les trous de ver pourraient agir de manière fortuite. On ne saurait pas nécessairement où, ni à quel moment on en émergerait. Les trous de ver et les machines à voyager dans le temps seraient donc imprévisibles et instables.

Jusqu'à nos jours, ni trou blanc ni trou de ver n'ont encore été détectés dans le cosmos...

Au cours de ce siècle, *les études canadiennes* ont énormément contribué à éclaircir les phénomènes intersidéraux. C'est à un astronome canadien, Thomas Bolton, que nous devons la découverte, en 1972, du premier trou noir de la Voie lactée, notre Galaxie. Il s'agit du notoire *Cygnus X-1*, situé à 8.150 années-lumière d'ici. En étudiant le mouvement oscillatoire d'une étoile super géante bleue surnommée *HDE 226868*, Bolton détecte la présence du trou noir et par le fait même, entre au panthéon de l'histoire de la cosmologie. L'observatoire David Dunlap, campé en Ontario à ce moment-là, devient ainsi l'hôte de cette prodigieuse trouvaille.

Cygnus X-1 et *HDE 226868* formeraient un système binaire. Dans un système binaire, les deux astres virevoltent l'un autour de l'autre, tel un couple engagé dans une danse de séduction. Le couple est formé d'une étoile dite normale et d'un compagnon invisible, soit une étoile éteinte (naine blanche, étoile à neutrons ou trou noir). Dans ce cas-ci, les observations de Bolton pointent vers la probabilité d'un trou noir. Ce dernier, en fait, attire l'étoile bleue dans son champ gravitationnel, comme une araignée tissant son piège pour ses proies insoucieuses. Le trou noir dévorera éventuellement sa victime céleste.

Figure 14 — Cygnus-1. Image: ESA, *Hubble*

En 2007, dans la galaxie voisine M33, située à 3 millions d'années-lumière de la Voie Lactée, des astronomes détectent à partir des données télescopiques de Chandra et Hubble, l'un des plus gigantesques trous noirs stellaires gravitant autour d'une étoile bleue de taille considérable. La masse du trou noir, communément connu sous l'appellation M33 X-7, a été évaluée à 15,7 fois celle du Soleil.

Figure 15 — M33 ou la galaxie du Triangle. Source : NASA, JPL-Caltech, GALEX

Au matin du 24 février 1987, depuis l'observatoire de Las Campanas situé au Chili, l'astronome canadien Ian Shelton de l'Université de Toronto découvre la supernova la plus lumineuse et discernable à l'œil nu depuis plus de 300 ans. Cette dernière se terre dans le Nuage de Magellan; elle sera baptisée SuperNova 1987A Shelton. Tenant compte de la distance, cet événement prodigieux contemplé il y a plus de vingt ans au eu lieu, en réalité, il y a 168 000 ans. Cette supernova s'est formée à partir d'une étoile ultra massive bleue, Sanduleac -69*202, ayant près de 20 Ms.

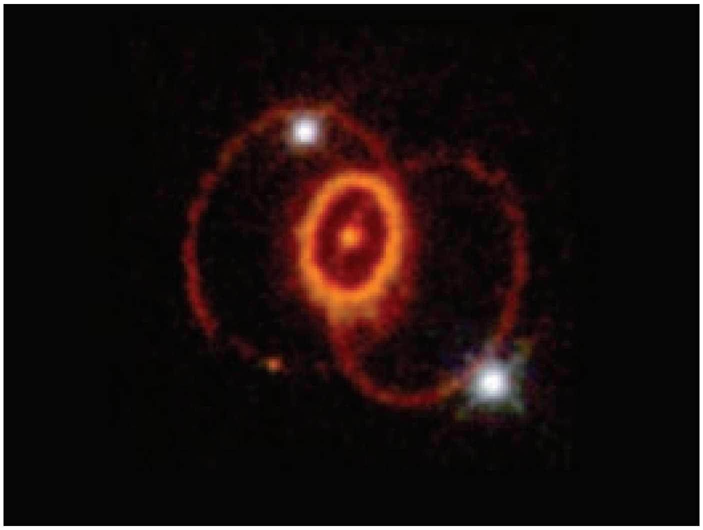

Figure 16 — Le rémanent de Supernova 1987a dans le Grand Nuage de Magellan. Source : NASA

Plusieurs astronomes supposent qu'à l'épicentre de toute galaxie, subsiste un trou noir gargantuesque, dont sa masse serait des millions de fois supérieure à celle du Soleil. Notre propre Galaxie en abriterait un à plus de 26 000 années-lumière de la Terre; Sagittarius A*. C'est en 2000, de par l'étude de la trajectoire d'étoiles en orbite, qu'Andrea Ghez (Université de Californie) et John Kormendy (Université de Texas) confirment l'existence de ce trou noir. Selon sa faible diffusion de rayons-X, ce dernier, d'environ 4 millions de masses solaires, serait de proportion moindre comparativement aux autres objets cosmologiques régnant au cœur des galaxies.

Selon le Conseil national de recherches Canada, en 1987, un astronome canadien fournit des preuves indiscutables qu'un trou noir supermassif trône au milieu de la galaxie d'Andromède (M31). C'est grâce au Télescope Canada-France-Hawaii (TCFH) que se réalise cette découverte. La qualité inouïe des images spectrales fournies par ce dernier a permis de calculer la vitesse de rotation des étoiles happées par le tourbillon gravitationnel.

Certaines étoiles tournent autour d'un trou noir à une vitesse supérieure à 1488 km/s, soit 50 fois plus rapidement que le mouvement révolutionnaire de la Terre autour du Soleil, et la vitesse ne cesse d'accroître. La vitesse de rotation de l'étoile se synchronise à celle du trou noir.

Le 24 juin 1999, le satellite FUSE (*Explorateur Spectroscopique Ultraviolet Lointain*) est mis en orbite par la fusée Delta II 7320-10. Ce satellite d'observation de la NASA est, en fait, un programme conçu sous la gérance de l'Université Johns Hopkins de Baltimore (États-Unis), en collaboration avec l'Agence spaciale canadienne and le Centre national d'études spaciales (le CNES), agence spatiale française.

Figure 17 — Sagittarius A* : Trou noir au centre de la Voie Lactée. Source: NASA/CXC/MIT/F.K.Baganoff *et al.*

Au cours de cette décennie, FUSE récolte une multitude de précieuses informations permettant d'observer les objets les plus éloignés et vétustes d'une galaxie : les quasars.

Ces quasars sont en fait des galaxies disposant d'un trou noir super massif en leur centre. L'étude du domaine spectral est, d'autant plus, facilitée par la luminosité de ces puissantes sources d'ondes radio.

Le 13 juin 2007, Chris Willott, professeur au Département de physique de l'Université d'Ottawa, en collaboration avec une équipe internationale, repère un quasar colossal situé à près de 13 milliards d'années lumières de notre planète, et ce, grâce au télescope Canada-France-Hawaii. Nommé CFHQS J2329-0301 d'après sa position dans la voûte astrale, ce quasar serait, en fait, le plus lointain de notre galaxie. Il importe de garder à l'esprit que l'étude de corps aussi lointains et anciens nous procure d'importants détails sur la formation de l'Univers. Plus un quasar est loin, plus est proche du début de l'Univers.

L'une des prédictions de la théorie d'Einstein va probablement jouer un rôle prédominant dans l'astronomie du siècle prochain. Il s'agit de l'existence d'ondes gravitationnelles.

Il existe une thèse selon laquelle des ondes gravitationnelles (aussi considérées comme des perturbations de l'espace-temps) seraient diffusées lors de l'effondrement d'une étoile massive. Ainsi, il sera peut-être bientôt possible de repérer un trou noir via les interféromètres conçus à cet effet : le détecteur franco-italien Virgo de Cascina, l'interféromètre américain LIGO ou le projet anglo-allemand GEO. La première observation directe déverrouillera la porte de l'astronomie gravitationnelle et permettra de sonder en profondeur la gravitation ainsi que la relativité générale.

Les trous noirs, ces captivants fossiles intersidéraux, ne cessent de nous stupéfier. Même si certains astrophysiciens restent persuadés de leur non-existence, il n'en demeure pas moins que les spéculations sont fondées sur de réelles observations. Chaque découverte en entraîne une autre et de nouveaux questionnements sont soulevés. L'homme, avec sa soif inaltérable de connaissances, repousse toujours ses limites plus loin, plus haut et l'espace est son ultime frontière.

Que nous réserve l'avenir?

Selon certaines images recelées par des télescopes spatiaux, l'expansion de l'Univers est en accélération, donc le nombre de trous noirs augmente perpétuellement. Inexorablement, toute la matière environnante sera engloutie par ces avaleurs avides. Ces sombres entités seraient-ils donc les cavaliers noirs de l'Apocalypse, précepteurs de la fin du monde? Heureusement que celle-ci est prévue d'ici quelques milliards d'années. D'ici là, il faudrait surtout éviter de dévaster davantage notre planète par nos guerres, notre pollution et notre désir destructeur de pouvoir.

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As part of the activities of the Canada node of IYA2009, the RASC History Committee sponsored *Canada and the Stars*, a competitive writing contest for Canadians to tell the story of Canada's record of achievement in astronomy and space science to other Canadians, and the world. The chosen topics could be on any subject with significant Canadian astronomical involvement, from pre-contact (ca. 1497) to the present. Support for *Canada and the Stars* was generously provided by the Ruth Northcott Memorial Fund. Gerardina Pasquariello was the first-place winner in the 18 years or older category, and her prize-winning essay appears above. The work of the other prize winners will appear in subsequent numbers of the *Journal*. The *Canada and the Stars* prize jury and the History Committee wish to thank all participants who helped to make this another IYA2009 success.

Gerardina Pasquariello is a delightful writer and gracefully shares with us her understanding of astronomy, a passion she has explored since childhood. She holds a degree in Communications from the University of Montreal (UQAM) and currently works in Corporate Events at the Standard Life Assurance Company of Canada.

Astronomy Outreach in Cuba: My Adventure

by David M.F. Chapman, Halifax Centre
(dave.chapman@ns.sympatico.ca)

This story begins in 2009, when I was having a pint at Stayner's, a local Halifax jazz bar, with my friend Phil Theriault. Phil is a retired teacher whom I met through the Atlantic Jazz Festival (now called the Halifax Jazz Festival). Phil was the Volunteer Coordinator in charge of recruiting and assigning the 450+ volunteers (including me) needed to run the nine-day festival every July. Over his pint, Phil described another volunteer opportunity, in which he leads a group to Havana University every spring to assist Cuban students in mastering the English language – not teaching, but language enrichment. He was trying to get me to join, but I was reluctant. "If I could teach astronomy in English, then I could get interested," I said. So I went home and came up with a proposal to present some introductory practical astronomy talks (similar to the Halifax Centre's NOVA program), and I added the possibility of a workshop with Galileoscopes, the special teaching kit developed for International Year of Astronomy 2009.

Figure 1 —The Galileoscope (photo courtesy Galileoscope, LLC)

To cut a long story short, we had a devil of a time getting anyone seriously interested in this, as Phil had contacts only at the Foreign Language School, and I had zero contacts! So my Plan B (astronomy lectures) was not looking promising, and I was going to have to resort to Plan A (English enrichment), as by this time I had committed to going. However, since Saint Mary's University (SMU) Department of Astronomy & Physics had pledged a number of Galileoscopes to support the project, I continued spinning Plan B for anyone who would listen. As you will see, what I ended up with was Plan C, which was better than Plans A and B combined!

After I accepted the 12 Galileoscopes from SMU, I resumed searching for contacts. Perhaps the fact that I was committed to coming and that I actually had the 'scopes (along with an official letter of introduction from SMU) made the difference, as this time I got an enthusiastic reply from Dr. Oscar Alvarez of the Cuban Ministry of Science, Technology, and Environment. Oscar was also the Cuban National Point of Contact for IYA2009, and was instrumental in setting up a new planetarium in Havana that had just opened in January 2010. Oscar put me in touch with Alejandro Jiminez, who, along with Oscar, was very much involved in astronomy outreach with amateur astronomers in Cuba. Plans developed rapidly in the last few weeks before departure, but it turned out that nothing was ever certain until almost the minute it started. Apparently, this is typical of Cuba.

Figure 2 — Dave Chapman and Alejandro Jiminez with a Galileoscope

The journey south was more eventful than we wanted, with us arriving a day late on 2010 March 5. It turned out that I had not done my homework, since despite all the great documentation I had regarding my project, Cuban Customs would not let me enter with my two large cardboard boxes of Galileoscopes. They held on to them and gave me an official-looking receipt. Honestly, I thought they were very nice about the whole business. They understood what I was doing and approved, but could not let the telescopes go. Several days later, Oscar and I returned to the airport and visited several offices, but no one would authorize their release, even considering that he is a well-known TV personality in Cuba. In the end, I formally signed them over to the Ministry and they took care

Figure 3 — A typical workshop

Figure 4 — Assembling the Galileoscope

Figure 6 — Oscar Alvarez, the Cuban IYA2009 Point of Contact, and the author

of the importation, which did not take place until I was back in Canada! At the time I write this, I am happy to report that Oscar and Alejandro finally have the Galileoscopes and have been putting them to good use in programs involving Cuban youth.

When I finally met Alejandro, I discovered a tall, thin, energetic man who is dedicated to astronomy and who never seems to sleep. We became instant pals. His enthusiasm was infectious, and I found myself swept up in his world for about a week. The idea of teaching a NOVA-like course was immediately tossed out the window, and we started on Plan C: teaching the teachers. I had had the foresight to assemble a single Galileoscope from my own stock and place it in my suitcase. No one even looked in my suitcase, but, had they done so, my truthful position would have been that it was my "personal" telescope, like my tripod, binoculars, camera, and computer. Alejandro and I built a presentation around that one Galileoscope and my *PowerPoint* presentation on the Galilean versus Keplerian telescope designs.

That week, I presented three Galileoscope workshops to about 125 people at the National Museum of Natural History in Plaza des Armes in Havana. My Galileoscope was put together and taken apart multiple times over that week! The first group included instructors, teachers, and planetarium volunteers, plus schoolchildren and some "explorer pioneers," who are the Cuban equivalent of Scouts and Girl Guides. The second and third groups were mostly senior elementary schoolchildren, but there were always adult amateur astronomers, observatory directors, science popularizers, and others in the mix. Each workshop began with a brief introduction by me, followed by a step-by-step assembly of the Galileoscope. I spoke slowly in English and Alejandro translated. We brought the audience up in groups to examine the telescope parts on the table, and then chose four young volunteers to perform the assembly steps. At the end, we set the telescope on a tripod at the window and everyone got to look through it. Across the Plaza, there were outdoor bookstalls, and the children amused themselves by reading the upside-down book titles in the inverted-image astronomical telescope. In the second workshop, we covered an advanced topic by explaining the difference between Kepler's astronomical telescope and Galileo's terrestrial telescope. To my amazement, Alejandro had converted my English *PowerPoint* presentation into a Spanish one overnight! I presented my personal Galileoscope to a lady living in Havana who was very helpful to my project in a number of ways. I loaned Alejandro my tripod for a year, as photo tripods seem scarce. I also left behind two copies of the RASC *Observer's Handbook* and a used copy of *Nightwatch*. These materials – even used – are deeply appreciated by the Cuban amateur astronomers.

Figure 5 — A first glimpse of the view through a telescope

Returning to an earlier part of my story, on our journey to the airport to attempt to liberate the donated 12 Galileoscopes, Oscar Alvarez surprised me by asking if I would record a short TV spot on the topic of UFOs and extraterrestrials. Cuban TV was planning to broadcast a documentary on the topic, they had lined up several "experts" to comment, and they wanted my perspective. I agreed - or rather, I could not refuse – and I ended up in a cavernous room in their Capitol Building one afternoon to shoot the piece. They asked me to answer the question: "Why do the vast majority of people believe that extraterrestrial beings routinely visit Earth in spacecraft?" I do not have a copy of my answer, as I more-or-less made it up out of my head, but it went something like this:

Figure 7 — The Havana Planetarium, once a cinema

This is an interesting question and I thank you for inviting me to comment on it. First, I should say that I am not a specialist in this area of study, so I can only answer in my capacity as an amateur astronomer and as a critical thinker. I am not convinced that the number of people who believe this assertion constitutes a "vast majority," but I accept that at least a significant minority of people believe in these phenomena, so I will continue on that basis. To start with, I should say that UFOs are real and dangerous. [Note: I stole this line verbatim from Prof. Roy Bishop.] You may be surprised to hear me say this, but I shall explain. UFOs are real because, in the vast majority of cases, people actually observe or otherwise sense a real experience; we have to assume that people do not simply make these stories up, for the most part. So, they see something in the sky that they cannot identify, in other words, an unidentified flying object. These UFOs are dangerous because many observers do not search for natural or anthropogenic explanations for what they perceive; they immediately jump to the most fanciful or outrageous explanations, such as extraterrestrials visiting Earth in flying saucers. When investigated rationally using critical analysis, time and time again, these so-called UFOs have turned out to have simple Earthly explanations. The fact that I am an amateur astronomer is relevant to this question for the following reason: the hundreds of amateur astronomers I know have spent thousands of hours looking at the sky, and yet not a single object has been sighted whose explanation demanded the involvement of extraterrestrials.

Now I will try to answer the specific question regarding why people believe in the extraterrestrial origin of UFOs. This is not a question for the physical sciences to resolve; rather it lies in the domains of evolutionary biology, psychology, and neuroscience. The one element that distinguishes humans from all other known life forms is our large brain. The evolution of the brain has allowed humans to imagine realities that do not yet exist. Hence we can develop tools to assist our work, design and build magnificent new buildings, create art works never before seen, compose music never before heard, and imagine stories of events that never actually happened. This imaginative capacity of the brain has allowed us to create wonderful things, but it has also left us with a boundary between fantasy and reality that can become blurred. As the scientific investigation of our own minds continues to unfold, we may improve our understanding of these UFO and other irrational beliefs, but there may never come a time when they entirely disappear.

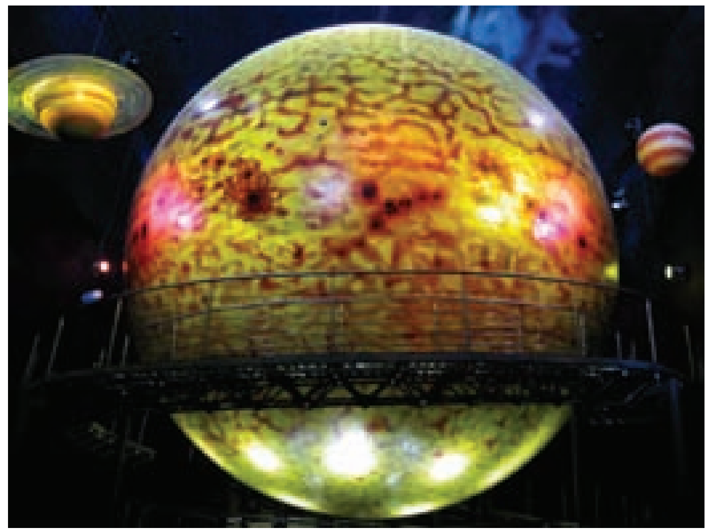

Figure 8 —The "Sun" houses the theatre and planetarium projector

Apparently, this clip appeared at the end of a science documentary on UFOs that aired on Sunday, April 25, after the news. I have no idea how it was received!

Before I left Havana, I took a group of 10 people (mostly Canadian visitors) to the new Havana Planetarium for a private tour. The nucleus of the building is a brand new optical-mechanical projector supplied by Japan. The planetarium building was temporarily closed for necessary repairs, but we were still able to tour the facility and to enjoy a brief demonstration of the projector. The views of the heavens projected onto the 10-metre dome were spectacular! The building is a former cinema in Plaza Vieja (Old Square) and is situated a stone's throw from the Havana Taverna, which brews its own beer. (For the duration of our visit, the Havana Taverna became our temporary HQ, much as The Henry House was for our IYA activities in Halifax.) The Planetarium Director - a woman whose name I forgot - invited me back to give my next set of lectures at the planetarium itself.

In conclusion, Plan C, which was not really a plan at all, turned out to be an enjoyable and productive session of astronomy outreach in Havana, with the added benefit of meeting new astronomy

Figure 9 — The planetarium projector, donated by Japan

friends. I have already started a discussion with Alejandro and Oscar about a return visit in 2011, so there may very well be an update next year.

This article was previously published with minor alterations in Nova Notes, the newsletter of the RASC Halifax Centre.

David Chapman became an amateur astronomer as a boy in Winnipeg. He joined the RASC first in Ottawa and again in Halifax, and has served in several capacities at the Centre and National levels. Professionally, he studied physics (B.Sc. University of Ottawa, 1975 and M.Sc., University of British Columbia, 1977) followed by 31 years of public service as a Defence Scientist, specializing in underwater acoustics. Since his retirement in 2008 he became an Assistant Editor of JRASC *and helps with Halifax Centre outreach and dark sky preserve activities, including communications for the* ad hoc *Astronomy Nova Scotia collective. He received the RASC Simon Newcomb Award (1986), the RASC Messier Certificate (1986), and the sabel K. Williamson Lunar Observing Certificate (2010)* – i.e. *he is a certified lunatic.*

Beyond IYA in Saskatchewan

by James Edgar, National Secretary (jamesedgar@sasktel.net)

During IYA2009, I was buoyed up with enthusiasm, distributing Star Finders to the local schools and getting sponsors to buy enough Galileoscopes to present three to each school in my community (Melville, Saskatchewan). It was a wonderful experience to get into so many classrooms and to speak to all the children. I calculate that I contacted each student in Melville at least twice throughout the year. In addition, I drove to the distant town of Preeceville to distribute Star Finders to an elementary school there. One of the teachers there is a friend's daughter, so my visit was by invitation through him.

I gave a talk on the stars to the Fort Qu'Appelle Nature Club. One of members of the club had heard about me, and extended an invitation to speak at their monthly meeting. The group of about 12 people were very appreciative, inviting me back in the spring to spend an evening under the stars.

One other outreach activity was to visit nearby Good Spirit Provincial Park, under the auspices of the Regina Centre. I spent one day with the park interpreters, showing them some of the ins and outs of a telescope, and giving some guidance on the use of different eyepieces and solar filters. The park has a 10-inch SkyWatcher telescope, so it was good to get the interpreters familiar with its use.

This year, as part of my continuing effort in the Beyond IYA era (BIYA), I wanted to visit the park again and give talks at some local classrooms. My first visit in 2010 was to return to the Fort Qu'Appelle Nature Group to give them a tour around the night sky, using my trusty green laser pointer (not pointed at planes!). The pointers are magnificent tools to show a group a specific star, constellation, or galaxy – too bad some silly people have to spoil their use through malicious behaviour. Even though the group was prepared for some late-April cold, the air became quite chilly as the night progressed, chasing some of the group away early.

My next outing was by invitation back to Good Spirit Provincial Park on July 9, where I gave a *PowerPoint* talk in the early evening to a gathering of about 20 campers. The park is about 45 minutes away from Melville by car, and so is an easy evening drive there and back. The sky darkened while I spoke, and by about 10 p.m. we were able to go outside for a little observing through the several Galileoscopes owned by the park, the park's SkyWatcher Dobsonian, and my own 10-inch Orion Dobsonian Intelliscope.

All would have been well except for the voracious mosquitoes – we were literally eaten alive! The little bug(ger)s were in our ears, under clothing, and munching away on any exposed flesh they could find – not nice!! I did manage (between bug slaps) to point out three planets to the west, Venus, Mars, and Saturn, plus conduct a hurried laser-pointer tour of the Milky Way. The cloud of bugs got thicker when the rising dew really messed up the telescopes, and it didn't take much to convince everyone that we would be better off inside the hall once again for more talks. A few of the assembled campers stayed around for another hour or more, while I showed video clips from the Solar Dynamics Observatory, the ALMA Project, and some images gleaned from the Internet.

Before all this happened, I was asked by interpreters at Greenwater Provincial Park if I knew anybody close to them who could give an astronomy talk to the campers there. I didn't, so I offered my services instead. They responded that their limited budget wouldn't allow them to even pay for my auto expenses, so that was pretty much out of the question. Then, during the panel discussion at the Fredericton GA, I posed the question to Dr. Jim Hesser, "Is there some way we could support outreach to remote locations, such as Greenwater Park?" His response was that money was available through the NSERC (Natural Sciences and Engineering Research Council of Canada) grant obtained in 2009 – Dr. John Percy in Toronto was the man to contact.

When I got back to Melville after the GA, I did just that, and got the support needed to pay my mileage to the park and back. It wasn't a lot of money, but the $150 helped out with expenses. Friends of mine live near the park, so I invited myself to stay overnight with them. With those arrangements in place, I was looking forward to an astronomy day at the park. I took along my Coronado Personal Solar Telescope and my Orion Dob with its solar filter.

John Percy's main criterion for the travel funding was that it was intended for people in underserved communities and for minorities – that was the premise of the NSERC application and grant. Greenwater Provincial Park is about as remote as you can find in central Saskatchewan – very underserved. If any of the campers were city folk, I would consider them underserved, too, since most have never seen the sky from a dark site.

The report I wrote for Dr. Percy, following my day at the park, says it all:

> *I'm pleased to report that my night under the stars at Greenwater Provincial Park turned into much more than that! I arrived at the park at noon, and spent the afternoon from 12:30 to 16:30 showing the Sun to campers and beach people through my Coronado PST and a 10-inch Dobsonian using a Thousand Oaks solar filter. Two park interpreters helped out aiming the scopes and explaining the Sun to viewers.*
>
> *I estimate that 150 people saw the Sun throughout the afternoon. Many youngsters went away, returning with one or both parents to show them, too. I was set up right in front of the ice cream stand, so people literally had to trip over me to get in line for a cone! Some of the adults hovered around, wanting repeat observations, listening to my explanations of the sunspots, the aurora, and such. Some were very surprised to hear that the Sun is not a hot rock, but a ball of gas undergoing fusion!!*
>
> *Later in the evening, I gave my Planetary Motion talk to 25 or so campers, many of them from the local area (and thus "underserved"). There was a 50/50 mix of adults and kids. These kids were very bright and asked profound questions – they have obviously been listening during astronomy instruction in the classroom.*
>
> *After about an hour, when we expected to view the trio of planets (Venus, Mars, and Saturn) to the west, clouds had moved in, blocking most of the sky. About half the crowd turned in, especially those with younger kids. The remaining dozen or so went back into the hall where I showed some of my aurora images, assorted pictures from Hubble, movie clips of the ALMA project, the "Largest Known Star," the "The Known Universe" (from The American Museum of Natural History), and some images explaining the Einstein Cross/gravitational lensing concept.*
>
> *Around 22:15, the sky had cleared enough that the crowd went out to the parking lot in front of the hall, where I gave a laser-pointer tour of the night sky, punctuated with views through my 10-inch Dobsonian of some of the more interesting objects (Mizar/Alcor; M13; M31; Albireo; The Coathanger; M81/M82; the Double Cluster in Perseus). There were many "Oooohs," and "Ahhhs" from kids and parents alike! Most rewarding!! After all the campers had drifted away, I was left with one of the park interpreters, so she and I packed my gear way, and then took in some binocular views of Jupiter, which had appeared in the east by then. I called it a day at 23:45.*

Figure 1 — A family of campers gets their first view of the Sun through my Coronado PST at the Greenwater Provincial Park beach.

Just today, October 4, I gave my Synthesis of Elements presentation to three high-school science classes in Melville. I hope to continue this BIYA activity for years to come!

Drawing at the Eyepiece

by Kathleen Houston, Saskatoon Centre (e.b.a@sasktel.net)

Kathleen Houston

Astronomy notebook entry: "After three nights and two-and-a-half days of sustained rain, thunderstorms, hail, and fog at Saskatchewan Summer Star Party, we truly earned our last but not least, *clear* Saturday night."

Some club members like to keep an astronomy journal or notebook, draw and describe with words what they saw, make notes on how to get there, record the conditions, degree of difficulty, and the triumphs. I was delighted with our hard-earned single star night at Cypress Hills Interprovincial Park in southwestern Saskatchewan, and decided to do something different for my precious star time – draw[1]. I had a hot new birthday present from my husband Rick to explore with: a 2-inch 41-mm Panoptic eyepiece by Tele Vue. I think that Rick was just as excited as I was about the new addition. With this "holy hand grenade" out-weighing last year's RASC General Assembly swap-table birthday gift, a well-used 13-mm Tele Vue Nagler, I had to find more counterweight for my 10-inch Meade Lightbridge Dobsonian reflector. I used a 2-pound ankle weight that I brought for the 13-mm eyepiece and added my Stephen O'Meara book, strapping them on with two bungee cords. Not very pretty, but very effective. I am sure Steve would be honoured!

The O'Meara Method

Stephen James O'Meara was the guest speaker at the 2009 George Moore workshop near Edmonton. His book *Deep-Sky Companions: The Messier Objects* has been my main resource on "how to get there" and read about the highlights of any given object. Steve includes a photo of the field, a go-to map as viewed through the eyepiece, and his sketches for each Messier object. He advocates spending extended time at the eyepiece: "Each drawing was based on several hours of observing each object over several extremely transparent nights." In the evening after the workshop presentations, I made sure to have a talk with Steve. I wanted to know more about his drawing process. He demonstrated his pencil work and described his technique. He begins in wide field and draws his guide stars and main details, gradually working up to more magnification. At each stage, he told me that he "exhausts all the details" before moving on. So, Saturday night I was motivated to try out "the O'Meara method." I wondered "what could I see," and "how far can I go?"

My 41-mm eyepiece staged for me a wider field of view that was more grounding with more guide stars. This eyepiece revolutionizes how I work. I felt well oriented before entering into the field with my 22-mm and 13-mm eyepieces. I started with the Lagoon Nebula to the south, because I like the variety of details of smoky textures and distinctive locally defining stars. I quickly realized how time consuming this was, but was keen to go the distance. I liked feeling connected to the stars in my field of view, as if I was introducing myself to them on an elemental level, somehow revealing their character to me. I savoured the pencil exploration of the diffuse luminous texture, wisps, and layering on my paper.

The Astronomer's Drawing Tool Kit and Darkroom

I was new to spending extended drawing time at the eyepiece, and needed to learn how to make a nighttime drawing-friendly environment, with the resources at hand. There are simple logistics. I have two hands, two eyes. I need to hold my clipboard, I have a telescope to manoeuvre, and if I am lucky, a seat that is the right height to keep me from wavering around while squinting through the eyepiece. My night drawing tool kit consists of a clipboard with paper, in my left hand, illuminated with a book flashlight with red gel, and a 6B pencil in the other. I even tried using an eye patch to cover the squinting eye, but found that drawing required two eyes, plus I preferred to simplify things. So, I made several attempts to position myself for the least fidgety and shortest pathway from eye to hand, making a juggler's job look easy.

Let's see, I need a light-free view at the eyepiece, and light on the paper for drawing: I minimized exposure to my red flashlight by flattening the head on my paper, to maximize my dark-adapted eyes when I was at the eyepiece. People walking around with relatively bright red flashlights were distracting while I was deeply focused on my task. They soon learned "be careful, Kathleen is drawing!" No I don't have a fancy hood or cloth over my head à la Sue French to shield stray light, to improve my darkroom. Is an astronomer's toolkit ever complete?

I went into the brightest nebulosity of the Lagoon, then followed the dark dust lane that Rick pointed out, and then across to the star cluster and its fainter nebulosity. Was that a smaller dust lane entering the star cluster? Rick suggested jiggling the eyepiece to allow the nebulosity to "jump out," which worked well but averted vision was better. A favourite of O'Meara is to inhale several times in a row to improve seeing by oxygenating. I recommend trying any or all of these to experience more from seeing in the dark. I wanted my eyes and instincts to take me "out there," explore everything my eyes could devour, and know this place so mysterious, intricate, and exciting.

I zoomed in from 41 to 22 mm and then to 13 mm, and then went back to the 41, zooming out to see how it all "reads" together. I suspect I took about an hour drawing the Lagoon Nebula. Then I moved on to the galaxy trio of M81, M82, and NGC 3077, a fainter

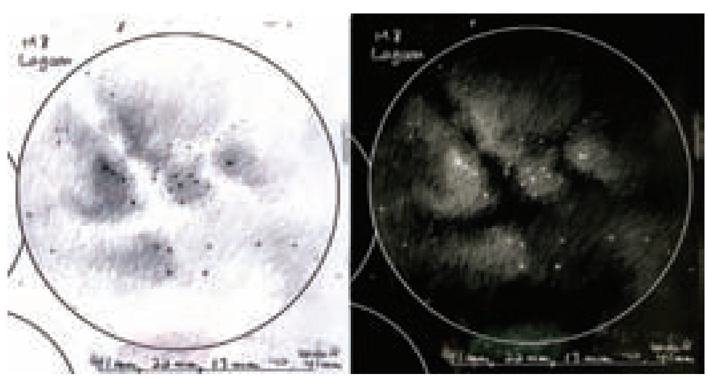

Figure 1 — The Lagoon Nebula, real and inverted drawings.

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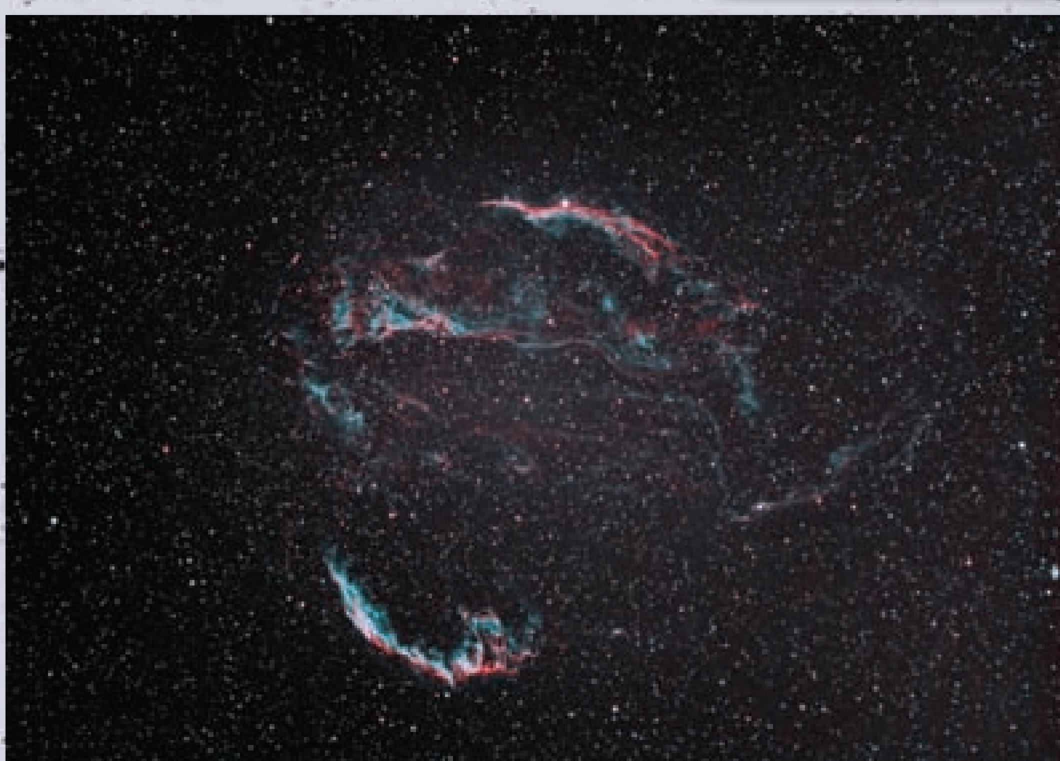
Pen & Pixel

(Above Left) Ottawa Centre's Rolf Meier captured Jupiter on August 1 as it was approaching opposition, using his Celestron 14 telescope with a SkyNix camera. In the 13-minute interval between the two exposures, Jupiter has rotated about half the diameter of the Great Red Spot. Planetary imagers are challenged to acquire movie frames of Jupiter very quickly because of the planet's rapid rotation.

(Above Right) Summer is now long gone, but Les Marczi's Eagle Nebula (M16) should bring back some warm feelings. The Eagle is an open cluster embedded in nebulosity in Serpens. The prominent bright edge to the dark nebula in the lower part is the famous "Pillars of Creation" that created a stir when *Hubble*'s image of the feature was first released. Les took the image from his back yard in July using a Canon XSi on an AP 130 telescope. Exposure was 50 x 4 minutes at ISO 800.



(Left) jim Chung hung his camera from the top of the telescope to get this wide-angle view of the Veil Nebula in Cygnus. The image is composed of 100 3-minute exposures taken through a 135-mm Zuiko lens at f/3 with a 3.2-megapixel QSI 532 CCD camera. Most observers are familiar with the upper portion of the complex next to the bright star 52 Cygnus, but the lower portion, NGC 6992/95 is also easily seen in dark skies.

(Left) The happy collaboration of Stefano Cancelli and Paul Mortfield brings us another spectacular image from summer skies. Over ten hours of exposure in August last year using an Apogee U16 camera on a 16-inch RCOS f/8.9 telescope were required to construct this view of the Trifid Nebula. Embedded in the red emission nebula, surrounding and below the central star, are several bright edges of evaporating gaseous globules showing where radiation from the hot central star is eating away at the densest parts of the star cloud. In contrast, the blue reflection nebula is a much quieter interstellar environment.

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fuzzy easily seen with averted vision. I tried to make sure I would move around from time to time, instead of just getting cold perched on Rick's terrific wooden observing chair. By 1:50 a.m., it was time for a more sustained break, and by then waves of light cloud were trickling in from the west, and contrast was poor. I wondered if Sue French's light-pollution filter might have been useful. My third drawing would have to wait until next time. Rick borrowed my new 41-mm gift, and went off exploring for himself. I worked on my drawing in the daylight before I felt it was complete.

Diverse Approaches

I looked for other examples of drawing at the eyepiece and found authors Mark Bratton and Sue French helpful. In *Celestial Sampler*, Sue French includes some of her terrific drawings, and advocates for note taking because it "has made me a better observer." She calls her astro pencil work "negative drawing (dark stars, white sky)." Her North America Nebula is particularly divine, as well as Bill Ferris's Helix, included in the book. I found two examples where French includes both the negative and the positive versions of a drawing, and in others where she compares a drawing with a photograph to show how seeing works.

I am a Mark Bratton fan. He showed me M81 and M82 in his 16-inch Dobsonian some years ago in Montreal at the Morgan Arboretum during a public star night, and I haven't looked back since. He also gave me advice on buying a telescope after I moved to Saskatchewan. As much as I enjoyed Bratton's article "Become a Better Observer: Sketch!," I was disappointed that he published only the positive (inverted) versions of his terrific drawings. I wish he included the original "negative drawings" on paper to demonstrate the process. The images look so photographic that a reluctant artist would be discouraged even to try. We don't see his style – the direction of the pencil as he darkens an area to produce the contrast and likeness of his object. When O'Meara drew for me, he showed me pretty much all that Bratton talked about, including smudging and erasing to clarify detail. And, yes, I asked Steve to sign the drawing!

O'Meara includes written observation descriptions in his book, as did Charles Messier in his journal. French states that "Writing a description or penciling a sketch forces me to pay attention and look for details." Seeing other people's stargazing notes and drawings helps me to participate in the sharing of their stories and experience, benefit from different approaches, and inform my own.

I have talked to many people about drawing at the eyepiece since George Moore's Workshop: Richard Huziak (Saskatoon Centre), Kim Hay (Kingston Centre), Sherry Campbell (Edmonton Centre), Jack Milliken (Calgary Centre), and others. There are many more astronomy sketchers out there, but they tend to be quiet about it. The drawing category is new at SSSP, as an extension of the photography contest and art display. At the RASC General Assembly last year, there were two superb sunspot drawings, and this year I was delighted with Regina teenager Jennilea Coppola's naked-eye full Moon entry. At SSSP 2011, I plan to host a drawing workshop with the objective of attracting more competition entries. Drawing is such a big adventure and each individual has a personalized reason to draw. What is yours? Clear skies and happy drawing!

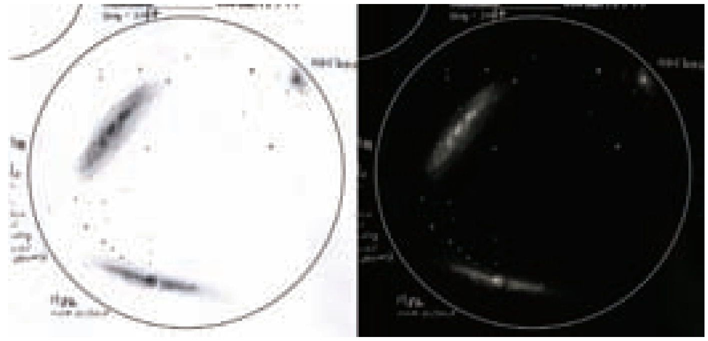


Figure 2 — Messier 81 and 82, real and inverted drawings.

Further resources:

Bratton, Mark (2009). "Become a Better Observer: Sketch!" *SkyNews*, July/August 2009.

French, Sue (2005). *Celestial Sampler, 60 small-scope sampler tours for starlit nights*. Cambridge, MA: Sky Publishing Corp. ISBN 1-931559-28-7.

O'Meara, Stephen James (1998). *Deep-Sky Companions: The Messier Objects*. Cambridge: Cambridge University Press. ISBN 0521553326.

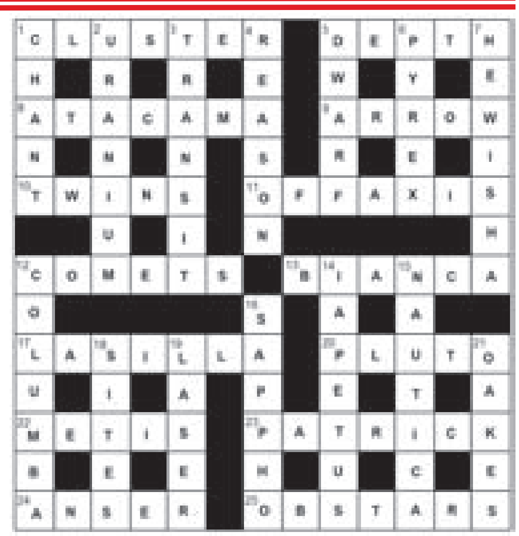
Kathleen is an artist and teacher and is a member of RASC Saskatoon Centre. She gave a talk at SSSP 2010 entitled "Holes in the night sky" on one rainy evening. She does digital "land art light drawing" and is involved in a group show at Eastend, SK. She welcomes tips on drawing, because one can never have all the angles!

[1] So, what is the difference between drawing and sketching? O'Meara uses the term drawing in his book *Deep-Sky Companions*, Bratton uses sketching in his *SkyNews* article "Become a Better Observer: Sketch!", and French uses both terms in "Celestial Sampler." I will use the term draw instead of sketch, and here is why. A drawing is intended to produce a substantial stand-alone work, whereas a sketch is a "quick unrefined drawing" (Wiki), usually as a preparation for something more substantial. Both drawings that I produced at SSSP took about an hour or more each, and were intended to explain my observation experience with as much detail as I could achieve.

Astrocryptic

by Curt Nason

The Solution to last issue's puzzle.



Cosmic Contemplations

by Jim Chung, Toronto Centre (jim_chung@sunshine.net)

Current Concepts in Planetary Imaging

With Jupiter transiting before midnight, the season for planetary imaging has arrived! In my inaugural article, I'll be reviewing the theory and fundamentals of planetary imaging, spanning subjects from the elegant simplicity of using an off-the-shelf Webcam, glimpsing state-of-the-art processing techniques, using machine-vision CCDs, and picking the best location on the planet from which to image.

There are three tenets to follow with planetary imaging:

1. The bigger the scope, the better.
2. The faster the camera, the better.
3. The quality of the seeing (or atmospheric stability) trumps everything.

A large-diameter scope allows you to gather more light, which provides a brighter image to the camera. This in turn allows one to reduce the noise in the image by reducing the need to amplify the signal (selecting a high gain) with the camera. This also allows one to use a shorter exposure. A larger scope also resolves more detail, rendering sharper, large-scale images. Chromatic aberration and costs typically rule out refractors, so Newtonian reflectors and Cassegrains are the favoured scope designs. In fact, Dobsonians represent the best value because an expensive high-capacity equatorial mount is not required. Hand tracking can be further enhanced with a relatively inexpensive, tracking Poncet platform.

The speed of the camera refers to both its shooting rate in terms of frames per second (fps) and its shutter or exposure speed. When visually observing a planet, one often finds fleeting moments of wonderful clarity and sharpness, reflecting the variation in atmospheric seeing. Even during periods of good seeing, there will be moments when the atmosphere seemingly disappears and one glimpses what a planet might look like when viewed from outer space. A short exposure speed will allow you to capture and freeze those moments of good seeing, and software will allow you to select only those frames for processing that ultimately will reveal a trove of hidden detail. A fast shooting rate will also necessitate an interface system capable of high-speed uncompressed data transfer. USB2 and Firewire400 can stream data at over 40 MB/s, which can support frame rates of 60 fps for a 640×480 pixel CCD. Firewire800 cameras now support 120 fps, and the new Ethernet GigE-enabled cameras promise even higher rates. This fast rate is critical for quickly rotating planets such as Jupiter, and allows the photographer to collect as much data as possible before the movement of the planet induces blurring.

Webcams are a great way to enter the realm of planetary imaging, although there are a few caveats. You must choose a Webcam that allows removal of its lens. Fortunately, threaded adaptors (Mogg) are available to connect the Webcam securely within the 1.25-inch barrel of a scope. Firmware updates are available for some models, which will allow uncompressed data transfer. This limits the shooting rate to less than 10 fps, but will improve the quality of the images. Finally, all Webcams are colour cameras that will reduce the resolution of the image due to the Bayer layer covering the pixels.

Figure 1 — A sample of planetary-imaging CCDs.

Machine-vision cameras with the fastest data interface are the choice of serious planetary imagers. Because of their price point, such cameras offer fewer circuit design compromises and better noise control by incorporating the most sensitive CCD chips, such as the Sony ExHAD. All cameras are monochromatic, which necessitates using a filter wheel populated with filters of the primary colours (R, G, and B) and obtaining data through each such filter. A flip mirror is also a useful device to allow stress-free alignment of the planet onto the tiny CCD chip. Centring a planetary image onto a CCD is a very difficult task, because most planetary imaging is done at high focal length, on the order of several metres. A zero-image-shifting motorized focuser is also most beneficial as it is *de rigueur* to refocus with every filter. Along with a motorized filter wheel, these devices also prevent the image-jarring tremors induced by touching any part of the imaging train.

Figure 2 — The imaging train.

Atmospheric seeing is the high-frequency image fluctuations caused by the mixing of parcels of air of differing temperatures. At its worst, bad seeing makes a planet pulsate and undulate like it is being cooked in a deep fryer. Most of the time it is seeing and operator skill that limits the quality of planetary imaging. Properly choosing your imaging site can mitigate several local seeing factors. Re-radiation of accumulated daytime heat from the ground and nearby buildings results in local convection currents – look for a moderately elevated site or a flat grassy field. Try not to image downwind of a city or a mountain range, since the air-flow will be turbulent. Imaging downwind of a large body of water or a plain will produce smooth laminar air-flow at your site. There are many useful Web sites to check the overhead wind conditions, such as the 300-mb (millibar) map plot at Unisys, SkippySky, and the Clear Sky Chart.

Do not attempt to image if it's windy, if a cold front has just passed, or if the stars are twinkling. High-altitude cirrus clouds at sunset can be a harbinger for good seeing, as is the presence of fog or mist, since poor transparency often coexists with excellent seeing. Finally, try to image the planet at its highest altitude since it will be furthest from the ground-level air turbulence and pollution, and you will also be imaging through a thinner section of the atmosphere.

True imaging purists will relocate temporarily to island mountain tops, like Hawaii's Mauna Kea, the eastern coast of Florida, the Caribbean islands, or Arizona/New Mexico – all locations where the seeing is consistently excellent. Imagers like me, who are stuck in the Great Lakes basin (amongst the worst seeing areas on the planet), have to wait patiently for the occasional night of excellent stability.

Clearly, a lot of effort is spent acquiring imaging data, and an equal amount of effort is required to process it! Typically, you will be operating in the field with a laptop, using capture software to record a movie of planetary images onto a hard drive. One should be prepared to have a lot of empty hard-drive space (at least 20GB). *Windows* users will be familiar with the public-domain software *Registax*, which has been continually refined throughout the years by its author. *OSX* users can choose from *Keith's Image Stacker* or *AstroIIDC*. These software packages perform a sorting routine to choose the sharpest frames among the thousands in a movie, and then stack those chosen frames. Stacking frames reduces the noise in the image in inverse proportion to the square root of the number of frames being added. Noise occurs as a random value, whereas a true image detail remains a constant pixel value, so the averaging function tends to increase the signal more rapidly than the noise. The noise is a result of the camera circuitry, as images are typically shot at moderate to high gain. Reducing the noise allows further processing to be performed on real planetary details and not noise artifacts. One of the joys of planetary imaging is being able to develop an image with better colour and resolution than is visually apparent at the eyepiece.

I would like to touch on some advanced processing techniques being used by planetary imagers. One is referred to as "multiple alignment point stacking," where you perform the stack several times but each time relative to a different alignment point. This can give you improved sharpness and clarity in the local region around each alignment point, as seeing does not remain constant over the entire image frame, especially when shooting a target such as the Moon with a large CCD (*i.e.* 1600 × 1200). Then it's a matter of cutting and pasting the different alignment-point regions together to form a mosaic image with improved sharpness throughout the frame.

Another technique applies to the special situation of a rapidly rotating planet such as Jupiter. Depending on the focal length utilized, you have approximately 2-3 minutes to acquire data before rotation makes it impossible to correctly align the frames in a stack. This effectively means that the photographer has only about a minute to obtain data through each RGB filter and at 30 fps that amounts to only 1800 frames. Add in time to refocus and rotate the filter wheel, and you may have to be satisfied with taking about 1000 frames per colour channel. This ultimately reduces the number of optimal frames available for stacking and noise reduction - hence the attractiveness of cameras that can shoot at 120 fps. *WinJUPOS* is public-domain software that allows you to derotate images. This means that you can spend the full three minutes shooting each colour channel. When you assemble your colour image, the individual RGB stacks will be widely out of alignment with each other because of Jupiter's rotation, but *WinJUPOS* will derotate them so that they can be correctly aligned!

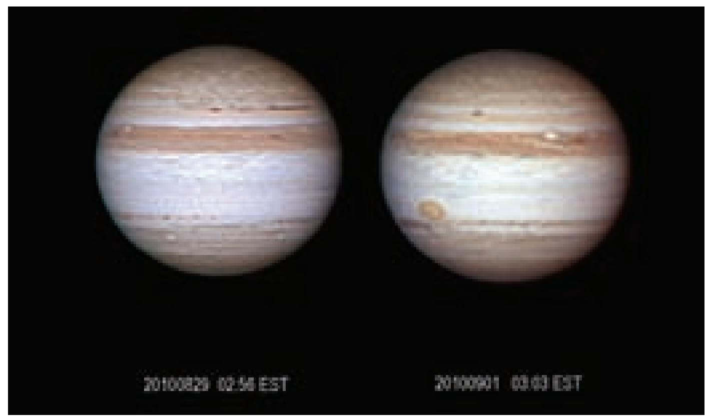
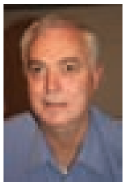


Figure 3 — Two Jupiters, from Toronto. These images were acquired by the author using a 12-inch Skywatcher Dob, a PGR Flea camera at 30 frames/second. Images are constructed from 250-400 frames in each of R, G, and B.

These are certainly exciting times for amateur astronomers, and progress is so rapid that information in publications tends to be quickly outdated. The best resources are usually found within one's local RASC Centre and on many online forums, such as Cloudy Nights. Despite the gear and despite the knowledge, nothing can replace dogged perseverance. A successful imager is only successful if he or she is out there every clear night, seizing those brief and elusive moments of perfect seeing!

Jim Chung has degrees in biochemistry and dentistry, and he has developed a particular interest for astroimaging over the past four years. He is also an avid rider and restorer of vintage motorcycles, which conveniently parlayed into ATM projects, such as giving his Skywatcher collapsible Dobsonian a full Meade Autostar GOTO capability. His dream is to spend a month imaging in New Mexico away from the demands of work and family.



On Another Wavelength

by David Garner, Kitchener-Waterloo Centre (jusloe1@wightman.ca)

HII Regions in Orion – The Running Man

Practically every observer has taken a look at the constellation Orion in one way or another. If you follow the belt eastward to the star Alnitak and then drop down halfway along the length of the sword, you come to an area known as the Orion Nebula. Also known as M42, this nebula is an enormous cloud of gas surrounding a cluster of hot young OB-type stars. M42 appears to be a faint star to the naked eye but when viewed through binoculars, becomes a nebulous patch of light.

The regions around M42 are quite interesting. There is a large star-forming molecular cloud, known as Orion Molecular Cloud 1 (OMC-1), hidden behind the dust in the Orion Nebula. OMC-2 and OMC-3, also major star-forming clouds, are located on the northern edge of the Orion Nebula. Approximately half a degree north of the Orion Nebula, and just above OMC-2/3, is a reflection nebula known as NGC 1977 (Figure1). To see this nebula clearly will require a larger telescope or one with a camera attached. Once you see the image, the reason for its name becomes obvious; the “Running Man” is for the most part a reflection nebula, with some emission and dark lanes, all in one. The dark lanes throughout the nebula appear to have the shape, as expected, of a running man. They are composed of thick clouds of interstellar dust that block the light of any stars behind them. The interstellar dust is typically made of iron particles and fine carbon grains.

Figure 1 — The Running Man Nebula, courtesy of Steve Holmes, Kitchener-Waterloo Centre. Image composed of 18×10-minute light frames. Steve used a QHY8 camera on a Tele Vue 101 refractor with 0.8NP reducer, giving an effective focal length of 430 mm.

Reflection nebulae are clouds of gas and dust that reflect the light of a nearby star(s). In this case, the UV radiation from the nearby stars is not sufficient to ionize much of the hydrogen gas in the nebula, so instead the nebula appears blue as it scatters the ultraviolet light.

When imaging the Running Man in colour, you can see slight tinges of red light. The H-alpha emission component of the nebula is due to ionization of hydrogen gas. The excitation causing most of the emission in NGC 1977 is from the B-type star known as HD 37018, which appears as the brightest star near the middle of the image.

The Running Man is actually composed of three nebulae; but NGC 1977, discovered by Sir William Herschel in 1786, is often used to identify the whole region. NGC 1973 and NGC 1975, discovered by Heinrich Louis d’Arrest in 1862 and 1864, are smaller nebulae located north of NGC 1977 that help to outline the image of the Running Man. The star HD 36958, as shown in the image, illuminates NGC 1973; further northeast HD 294262 illuminates NGC 1975. The overall size of the nebula is approximately 30 by 40 arcminutes.

The apparent magnitude of this nebula is listed at 7.0. The stars within the nebulosity are not difficult to see, but the gas and dust surrounding them is not so easy. It is estimated to be 1500 ly away, and can be found at right ascension $05^h\ 35^m\ 33.0^s$ and declination -4° 47′ 51″ Check the map in Figure 2 to get started.

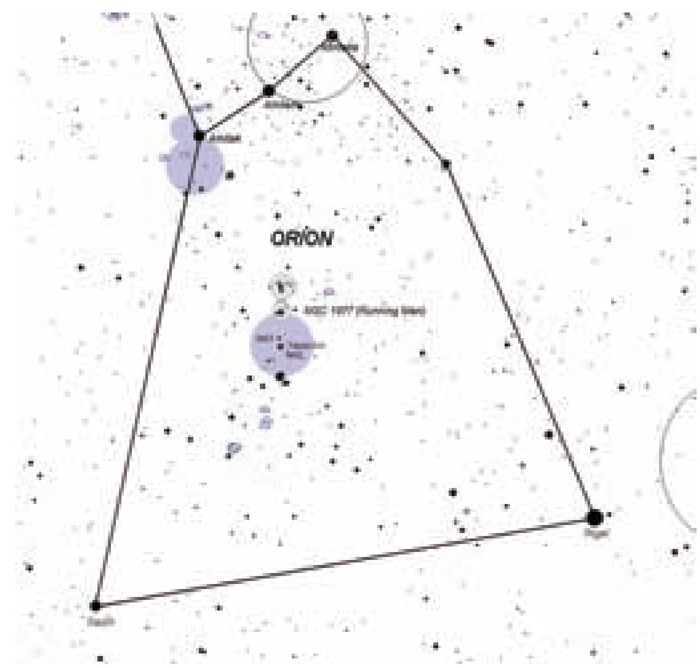


Figure 2 — A map of the southern half of the constellation.

Dave Garner teaches astronomy at Conestoga College in Kitchener, Ontario and is a Past President of the Kitchener-Waterloo Centre of the RASC. He enjoys observing both deep-sky and Solar System objects and especially trying to understand their inner workings.

Imager's Corner

by Blair MacDonald, Halifax Centre
(b.macdonald@ns.sympatico.ca)

Calibration – The First Steps

For those Red Green fans in our readership, consider this column the astrophotographer's version of Handy Man's Corner without the duct tape. Our illustrious Editor put out the call for articles to fill the pages of the *Journal*, and, as I have been receiving a few requests for information, I thought I'd combine the two into this column. Schedule permitting, I'll try to answer some of the questions as they come in, and I'll publish a few along with the answers in this column. Remember, this column will be based on your questions, so keep them coming or I'll have to make them up! You can send them to me at the address above. Please put "IC" as the first two letters in the topic, so my email filters will sort the questions.

This question for this edition is "What is image calibration and how is it done?"

The answer to this one is, as usual, simple and very complex. The simple answer is the one we will concentrate on here, as it provides the most insight into what's going on with the process. First then, calibration is simply a process for correcting the image data for imperfect detectors and optics. It's the first step in the image-processing workflow before stretching, flattening, or noise reduction.

Step one is to remove the *dark signal* from the image. You will notice that I used the term signal and not noise as it is commonly referred to in some camera literature. Noise, in the signal-processing sense, is a random variation in the data; there is nothing random in the dark signal (not quite true, but more on that later). The dark signal comes about because of thermally induced currents in the detector chip. At any given temperature, a pixel will accumulate a certain number of electrons due to this current, and it varies slightly from one pixel to the next. The only way to stop this signal is to cool the detector chip. This signal declines with temperature and will disappear completely at 0 Kelvin (this is why most astro-only CCD cameras are cooled). The good news here is that this signal is almost (notice I said almost) totally predictable. By taking a dark frame, which is an exposure of the back of your lens cap (*i.e.* no light reaching the detector), and subtracting it from the light frame (the image data), much of the dark signal can be removed. This works because the pixels collect the same amount of dark signal as they did during the light frame, so simple pixel-by-pixel subtraction removes it. This is what some digital cameras do for long-exposure noise reduction. The process is shown in the images at right, beginning with the first – a DSLR image of the Pelican nebula including the dark signal (Figure 1).

Now let's zoom in on the area around the Pelican's neck (Figure 2), and then take a look at the same area in a single dark frame (Figure 3).

When the dark frame is subtracted from the light frame, the result has significantly less thermal signal as shown in Figure 4.

Figure 1 — From-the-camera image of the Pelican Nebula.

Figure 2 — Enlargement of the neck area of Figure 1

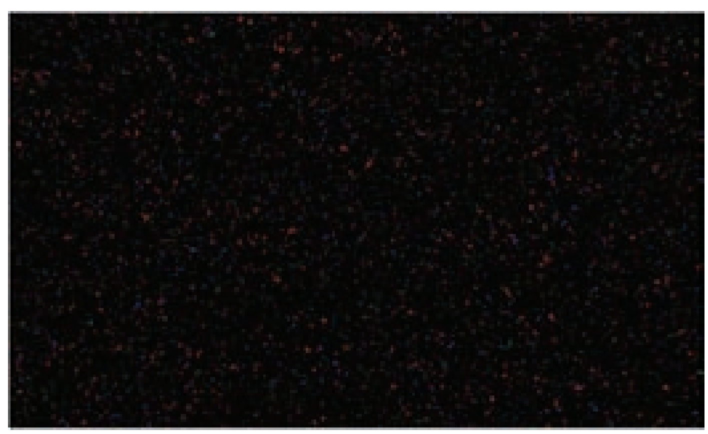


Figure 3 — A section of a dark frame.

Now for the bad news! There is a random component to the dark signal. This is the actual noise, and it varies with each exposure. Its magnitude is approximately equal to the square root of the number of electrons of dark signal collected during the exposure.

Figure 4 — Image with dark frame subtracted.

This is true noise, and subtraction will not remove it. The longer the exposure, the worse it gets, which is why it is not a good idea to simply subtract a single dark frame from a single light frame. Instead, you should always make a master or average dark frame from many individual darks. As you average the dark frames, this noise reduces with the square root of the number of darks in the average. If you use this master dark frame for dark correction, then you add less noise to the resulting light frame, producing a much better image in the end.

Many people compare the dark signal to film grain. It's not really a good comparison as the film grain varies shot to shot and cannot be removed by subtracting one negative from another. Chalk one up for digital imaging (oh, I can hear the protests from the purists now).

I've skipped bias calibration in this discussion because the bias signal is included with the dark frame. Bias is a signal that shows up in each pixel due to electrical bias currents in the semiconductor junctions of the detector. It is constant with exposure time and temperature, and even shows up in a zero-second exposure. The solution here is to simply take a series of very short exposures (as short as your camera can manage), average them to reduce that pesky noise, and then use this master bias frame to subtract the bias signal from both the dark and the light frame. If you simply subtract the dark frame, the bias is automatically removed, but the bias frame becomes important in the next step, flat-field correction.

Flat fields are used to correct for pixel-to-pixel sensitivity differences, and as a bonus, they also correct for some optical problems. The idea here is that if you take an image of an evenly illuminated flat white card (or the sky) then the image should have all the pixels set to the same value. Unfortunately, all the pixels on the chip do not have the same sensitivity, so the image will have variations in the pixel values that map to the differences in sensitivity. If you simply divide the dark-corrected image by the flat field, the effect of this varying pixel sensitivity is removed.

A single flat field is shown in Figure 5, where the variation in sensitivity caused by vignetting in the optical train is easy to see. The corners of the image are darker than the centre, the classic telltale sign of vignetting.

One point of note here: the bias signal should be removed from the flat field, and if the exposure is long enough to have significant dark signal, it should be removed as well. Generally speaking, the flat field is normalized to some value (if floating point math is used, then you simply normalize to the brightest pixel). If your optics vignette or if there are dust bunnies on your optics, then these reduce the amount of light making it to the sensor, and it looks like a sensitivity change, so a flat field can correct for these problems as well. The final calibrated image is shown in Figure 6.

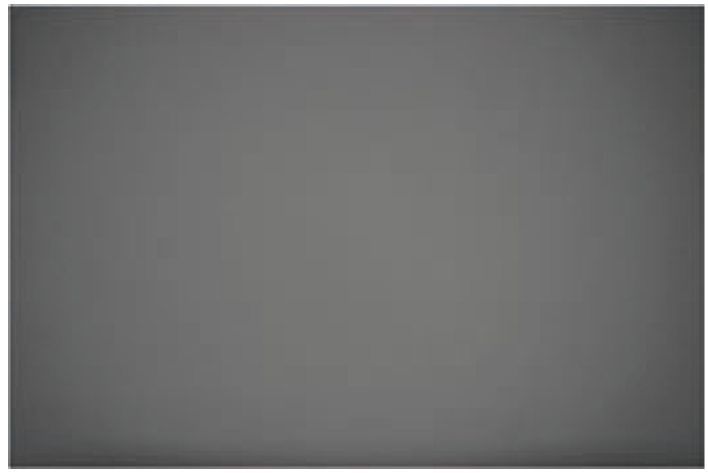


Figure 5 — Flat-field image. Note the effects of vignetting.

Figure 6 — The final corrected image of Pelican.

It needs averaging with additional frames to reduce the overall noise in the image, but it's not bad for a single five-minute DSLR exposure.

That is really all there is to it. Calibration allows the astro-imager to remove much of the non-ideal response of the imaging sensor from the image. This allows follow-on processing to correct colour, brightness, and contrast of the image to get that pretty picture we all want to hang on the wall.

Blair MacDonald is an electrical technologist running a research group at an Atlantic Canadian company specializing in digital signal processing and electrical design. He's been an RASC member for 20 years, and has been interested in astrophotography and image processing for about 15 years.

Astronomical Art & Artifact

R.A. Rosenfeld, RASC Archivist
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RASC Reform and Renewal

In the universe crafted by human perception, the non-living, the notionally living, and the doubtfully alive are enlivened through biological models, metaphors, and analogies. Precocious primates didn't start this in the wake of the *Origin of Species* (1859); the practice is ancient, predating the rise of Academic dialectic and Peripatetic physics. At present, we hardly stop to think what it means to speak of political institutions with *nerve-centres* of operations, *heads* of government, legislative *arms*, and... other parts. Without question, it just seems right to consider people grouped in formal or informal association pursuing common goals as somehow *corporate*, that is, forming a body. It is a useful conceptual device. Biological entities are constantly adapting in response to their environments; those that don't respond appropriately to changing conditions may find themselves all too late numbered among the late. If the analogy is worth anything, it holds for metaphorical bodies as well. And the RASC is one such body.

Those RASC members lucky enough to be endowed with their own central nervous system will know that the Society is engaged in a developing process of adaptation to a changing environment. Amid an ever-evolving Canadian demographic, we are a greying and rather uniform membership with a fugitive youth component and a not inconsiderable volunteer deficit. Our current President, Mary Lou Whitehorne, has kept readers of the *Journal* well informed of the necessity for change, and of the necessary options, speaking *ex cathedra* from the Paper Balcony ("Executive Perspectives": *JRASC 103*, 2009 June 3, 94-95; 104, 2010 February 1, 2-3; 104, 2010 April 2, 42-43; "President's Corner": 104, 2010 October 5, 174-175). National Council's deliberations on these concerns are freely available to members through the minutes archived on rasc.ca (a most useful fossil record). David Levy has even devoted an episode of *Let's Talk Stars* (2010 July 8) to the problem of why, when, where, how, and into whom the RASC should evolve (`http://letstalkstars.com/media/2010/WMA/20100708.wma`).

The evolutionary impasse at which we find ourselves is common to astronomical organizations on the same species-at-risk branch of the evolutionary tree. It is a crowded place to be. At times it feels as if we may as well be lost in space.

Before carving *"DON'T PANIC!"* on that branch in a desperate attempt to appear calm while witnessing RASC entropy increase, it might be encouraging to reflect that this is not the first time the Society has perceived the need to remake itself (Broughton 1994, 1-33). Further reflection would suggest that previous efforts must have met with some success; otherwise you would not be reading this. There was talk of reform and renewal in the early 1890s, when the Society experienced what might be termed its first rebirth (attended by midwives, or effected by resurrectionists?), and some of the problems identified then are strangely familiar.

Charles Carpmael, M.A., FRAS (1846-1894; Broughton 1994, 2), the director of the Toronto Observatory and a presidential predecessor of Mary Lou Whitehorne, early in 1890 drafted a "circular" to raise interest in the Astronomical and Physical Society of Toronto, as the RASC was then known. The "circular" is, in fact, our earliest surviving membership brochure. It is a prospectus that speaks more of potential membership benefits should the Society develop as its leaders hoped, rather than of the Society as it then was:

> "This Society desires to promote and encourage the study of astronomy and physics in Canada. For that purpose, ***it proposes to acquire*** a valuable reference library and suitable apparatus and instruments. Its printed Transactions ***will*** contain...Correspondence ***will*** be conducted with distinguished professional and amateur astronomers...The Society desires to be popular in the best sense of the word and, therefore, cordially invites to membership any one who takes a sincere interest in astronomical and physical matters, be his or her scientific qualifications what they may. It is confident that through the medium of its meetings and publications, ample return ***will*** be made to its members." [bold and italic are editorial; RASC Archives, 1890 minutes folder, typescript circular, p. 1-2][1]

Whatever the recruitment success of the circular, all did not seem well by the fall of that year. At the regular meeting on October 7:

> "It was moved by Mr. G.E. Lumsden seconded by Mr. Clarence Bell that a committee be appointed by the president to consider and report upon the best means of carrying out the objects of the Society. Carried. The Chairman appointed the following[: –] Mr. G.E. Lumsden – R. Dewar – D.J. Howell – Clarence Bell – T. Lindsay – A.F. Miller." [RASC Archives, 1890 minutes, p. 45][2]

The Committee worked fast.[3] Less than a month went by before its first report was finished on October 21, and at the regular meeting of November 4, a motion to have *both* it and their shorter second report "received and adopted" was unanimously carried. By implication, if not outright statement, the report was the fruit of one evening's meeting "at which many practical suggestions were submitted and discussed."[– by the Committee alone, or by members at large?]

The report identifies the necessity to:

> "still further stimulate members to take a more active interest in [the Society's] work and, thereby, in each case make the success of your Society a personal matter. It seemed to your Committee that while it would be injudicious even to appear to impose upon members any conditions to be met, or duties to be performed, it would be highly expedient to cause it to be understood that your Society would welcome any attempt on the part of any one to make its meetings interesting and profitable." [RASC Archives, 1890 minutes folder, Committee Report 1890 October 21]

Among the measures recommended, four stand out:

> "1. That...it be the policy of your Society to encourage, within

reasonable limits, the preparation of original papers upon astronomical or physical subjects.

2. That a List of the Dates upon which the meetings of your Society fall during the winter be made out and that each member...permit his name to be entered in the said List opposite the date or dates upon which he expects to be able to read a paper...

4. That at the discretion of the President, one meeting in three be, in advance, declared to be an open or conversational meeting at which general discussions may take place and questions submitted in writing at previous meetings, may be answered.

5. That if the questions so submitted be such as require study or research, it be discretionary with the President to refer them to such member or members as shall be willing to prepare answers to them." [RASC Archives, 1890 minutes folder, Committee Report 1890 October 21]

What do the concerns and measures of 1890 have to teach us today? From the preamble to the Committee's first report, it is blindingly obvious that 120 years ago we had a volunteer deficit. Just because a "tradition" is old doesn't mean it's wise.[4] From point 1, it appears there was a wish to foster an intellectually active Society, capable of contributing to the growth of astronomical knowledge, not just furthering its dissemination. Point 5 indicates that a metaphorical body responding to a stimulus had better do more than wave any old member any old way; the right response is always a competent one. In the 1890s, it was bad form to extract an answer from one's fundament to meet an honest astronomical query. It still is. Quality matters. Point 4 recommends the cultivation of variety in the Society's offerings - advice that is never dated. Item 2 recommends planning, planning, planning, if success is the desired outcome.

Wisdom is also to be found in Charles Carpmael's "circular." A popular Society is one in which those of any and all levels of scientific qualification, knowledge, and ability can feel welcome, its programmes characterized by attractive depth and breadth. And it is essential for survival to be connected to the wider astronomical world. Cooperation – both national and international – is a winning strategy in our game, and is requisite for astronomical progress at any level, professional or amateur. No Society can afford to have the metaphorical shape of a Klein bottle.

References

Manuscripts

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RASC Archives, 1890 minutes

Books

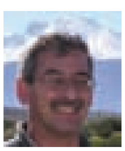
Broughton, R. Peter (1994). *Looking Up: A History of the Royal Astronomical Society of Canada*. Toronto & Oxford; Dundurn Press

[1] Membership was $2, which is ca. $55 in today's currency.

[2] Brief sketches of the Society activities of most of these figures can be found in Broughton 1994.

[3] This body never seems to have had any official name other than the faintly ominous sounding "the Committee." Fortunately, it proved rather more benign than "The Council" of the *Star Trek: Enterprise* 3rd season, the Harlem drug syndicate of the same name, or the infamous Venetian institution of the "Ten."

[4] In contrast to the Archivist and Managing Editor, who are both old and wise.



Second Light

by Leslie J. Sage (l.sage@us.nature.com)

A Massive Neutron Star

Neutron stars are one of the end points of the evolution of relatively massive stars after a supernova. They have masses greater than ~1.4 solar masses ($M_{\odot}$) and a less certain upper limit, beyond which the object becomes a black hole. Compact objects with masses more than 3 $M_{\odot}$ are black holes, but just where the dividing line comes depends upon details of nuclear physics and special relativity that are at present unclear. There is, therefore, great interest in finding massive neutron stars, to understand just what the upper limit might be. An important step was recently reported by Paul Demorest of the National Radio Astronomy Observatory and his colleagues, when they were able to demonstrate that the neutron star known as pulsar J1614-2230 has a mass of 1.97±0.04 $M_{\odot}$ (see the October 28 issue of Nature).

A pulsar is a rotating neutron star that emits radio waves from a spot on its surface (the specific process remains unclear). If the spot happens to be pointing at us, it is like a lighthouse beam sweeping over us. Pulsar J1614-2230 is in a binary system where the other component is a white dwarf.

The lower mass limit for neutron stars corresponds to the upper limit for a white dwarf, which is set by the Pauli exclusion principle – the rule that no two fermions (electrons in the case of a white dwarf) can occupy the same quantum state at the same time. This exerts a pressure that counters the inward force of gravity. Once the critical mass of 1.4 $M_{\odot}$ is exceeded, the electrons get forced into the protons, with the result that the object is almost entirely made of neutrons, and at a density approximately equal to that of an atomic nucleus. The "almost" and "approximately" are important in this context, because those words hide a world of physics about which we are quite unsure.

Theorists have been writing papers for years about the possibility of "quark stars," where some fraction of the neutron star has transcended pure neutron matter and become free quarks. Such quarks have a different "equation of state" than neutron matter, where the equation of state is simply the relationship between pressure and volume. For example, in air at room temperature, the volume is inversely proportional to the pressure. The pressure provided by neutrons alone is different from the pressure resulting from some portion of the star being free quarks, and some portion neutron matter. Other even more exotic mixes of matter have been proposed.

It is impossible to study bulk matter at nuclear densities in the laboratory, which is why many physicists are interested in the properties of neutron stars. When the stars are rapidly rotating as pulsars, very precise measurements of the timing and properties of the pulses allow astronomers to estimate their sizes, and if the pulsars are in binary systems, their masses can also be estimated. Hitherto, no sizes have been determined with sufficient precision to constrain meaningfully the equation of state of a neutron star. (Though many attempts have been made, none have withstood scrutiny.) Some neutron star masses have been measured to high precision, but have all clustered around 1.4 $M_{\odot}$.

The breakthrough with pulsar J1614-2230 came with the use of the "Shapiro delay." The general relativistic Shapiro effect is a slight change in the light travel time of photons moving through the strongly curved spacetime near the surface of a compact object (see the figure). The orbital plane of the binary is tilted by only about one degree to the line of sight, so when the pulsar is behind the white dwarf from our perspective, the radio waves travel very close to the surface of the white dwarf, where the delay is induced relative to other configurations of the orbit. This allowed Demorest to determine the mass of the neutron star quite precisely, and to be very confident that it is high.

Armed with the mass measurement, Demorest can already exclude most of the exotic types of matter proposed to be inside neutron stars. Quark matter is still allowed, but the quarks cannot be "free" – they must still be interacting strongly, almost like they were still inside the neutrons.

Normal pulsars are born in the chaos of a supernova explosion, and typically rotate about 30 times a second, gradually slowing with time. Most have masses not very far above the lower limit of 1.4 $M_{\odot}$. Millisecond pulsars like J1614-2230 – those that rotate about 300-1000 times a second – are thought to have accreted gas from a nearby companion star, and been "spun up" by the angular momentum of that gas. All it takes to spin them up is a few hundredths of a solar mass, so Demorest and colleagues suggest that J1614-2230 was born with a mass ~1.9 $M_{\odot}$, which means that there might be many more massive neutron stars to be found.

Even though I am an astronomer, it never ceases to amaze me what details we can figure out about the Universe just by collecting photons!

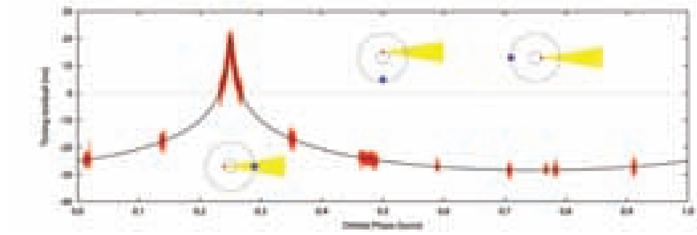


Figure 1 — This shows the timing "residuals" that result from subtracting the best-fit timing model, and the configuration of the neutron star and its companion in their orbit. The triangular peak is the Shapiro delay that arises when the neutron star lies behind the companion star. Figure courtesy of Paul Demorest and *Nature*.

Through My Eyepiece

By Geoff Gaherty, Toronto Centre (geoff@foxmead.ca)

Guidebooks

As promised last month, this time around I will look at the books that I find helpful in planning my observing sessions.

Back in the 1950s and 1960s, the main guidebook for amateur astronomers was *Olcott's Field Book of the Skies* (Putnam). Although highly recommended by my mentors in the Montréal Centre, I found it old fashioned, out-of-date, and rife with errors. It gave a lot of lore about constellations (which I must confess has never interested me much) and a very uneven list of objects, mostly double stars. It really was more suited to a naked eye or binocular observer, and had little to challenge even my tiny 108-mm reflector.

When I got back into astronomy in the 1990s, a wide collection of field books had become available. The bible of the day was *Burnham's Celestial Handbook* (Dover): three hefty volumes printed from typewritten manuscript. Although much loved by many, it somehow never appealed to me – maybe because by then even my little computer offered proportional type.

Since then I've purchased and pored over just about all the guidebooks that have come on the market. Here are the ones I find most useful and recommend to today's beginners.

Dickinson, Terence (2006). ***NightWatch*** **(4th ed.). Richmond Hill, ON: Firefly Books.**
Among its many strengths, Terry's classic book contains a singularly useful combined atlas and field guide for those just starting out on their astronomical adventures. Like everything else in the book, it shows a great deal of thought in its layout and selection of objects. How lucky we are to have Terry!

Pennington, Harvard C. (1997). ***The Year-Round Messier Marathon Field Guide.*** **Richmond, VA: Willmann-Bell.**
This is the best of the many Messier books. Others may have prettier pictures and more flowery descriptions, but Pennington gives us the most practical and thorough guide for use at any time of year.

Kepple, George Robert, & Sanner, Glen W. (1998). ***The Night Sky Observer's Guide.*** **Richmond, VA: Willmann-Bell**
Though marred by errors, this is the most comprehensive annotated guide to deep-sky objects beyond Messier's catalogue.

Harrington, Philip S. (1997). ***The Deep Sky: An Introduction.*** **Cambridge, MA: Sky Publishing.**
Harrington has written many fine observing guides, but this has always been, for me, his finest work. I'm particularly fond of his many beautifully reproduced drawings of deep-sky objects, for once printed on high-quality paper.

Finlay, W.H. (2003). ***Concise Catalog of Deep-Sky Objects.*** **London: Springer.**
Not a field guide, but an invaluable reference from our own Warren Finlay. Technical data on all the Messiers and all the deep-sky objects in the other two standard lists: Alan Dyer's Finest NGC Objects in the *Observer's Handbook* and the Astronomical League's Herschel 400, compiled by our dear old Lamplighter, the late Fr. Lucian Kemble.

In addition to these, a good planetarium software program will let you plot transient objects like asteroids and comets. I have my own favourite, but most of them will do the job admirably.

Geoff Gaherty recently received the Toronto Centre's Ostrander-Ramsay Award for excellence in writing, specifically for his **JRASC** *column, Through My Eyepiece. Despite cold in the winter and mosquitoes in the summer, he still manages to pursue a variety of observations, particularly of Jupiter and variable stars. Besides this column, he writes regularly for the* Starry Night Times. *He recently started writing a weekly column on the Space.com Web site.*

Gizmos

by Don van Akker, Victoria Centre (dvanakker@gmail.com)

Star Power

Our home on Salt Spring Island is off the grid, not because power isn't available there, but because of the appeal of the more basic lifestyle that is forced upon you when you can't rely on electrics to do the work. Without power, you can do almost anything except astrophotography. Modern mounts and photographic equipment require electricity and there is no way around that. At Springwater, we use star power.

Astronomy might be one of the few endeavours in Canada for which solar electric is really well suited. This is because during the summer, when we are most likely to have clear skies, we also have the longest days and the brightest sunshine, allowing for the quickest re-charging. In winter, when days are short and the Sun is dim, we don't get many clear nights so the low current produced by the solar panels has lots of time to charge the batteries.

A solar-electric power system consists of four main components. First, of course, are the panels themselves. We use two Sharp 80-watt "photovoltaic modules." The reason for this choice? They were available in our area. They are mounted on the roof of the observatory, which is sloped to accommodate them. There are various thoughts on what the angle should be, but if the panels are fixed, they should be angled steeply to take maximum advantage of the winter Sun. One rule of thumb is "latitude plus about 12 degrees." This puts the panel square to the Sun at its highest daily point on the dates midway between the equinoxes and the winter solstice.

Figure 1 — The roof was built to accommodate the panels. They would need a support frame to get the right angle anywhere else.

With solar panels to collect the Sun's energy, we need some way to store it, so the second main component is the electricity storage system. Ours consists of four 6-volt, 220-amp-hour golf-cart batteries. Fully charged, these will keep the observatory going all night and still have enough power to close the roof at the dawn. The idea is to have plenty of capacity, because even deep-cycle lead-acid batteries go downhill fast if they are discharged too much or too often.

Figure 2 — The inverter and controller mounted on plywood. The plastic cover on the right covers a large in-line fuse for the inverter, and the unit on the left is a multiple fuse block to protect 12-volt circuits.

Lead-acid batteries are also fussy about how they are charged. Although just connecting the solar panels to the batteries will work for a while, it will be a short while, so the third main component is a charge controller. This converts the varying voltage coming from the panels to the optimum voltage for charging batteries and, when the battery is charged, turns the voltage off.

The fourth main component is the inverter. We use a Xantrex 1800-watt inverter with a built-in transfer switch and a remote-mounted control. This provides output approximately equivalent to a standard wall outlet – far in excess of what is needed to operate a computer and a mount and a camera, but just about right to operate the half-horse motor that rolls the roof off.

Figure 3 — The remote switch is located beside the door. The readout can show input voltage or current drawn from the batteries.

If you are designing a solar electric system, make sure wire sizes are adequate. To roll back the roof, the inverter draws between 40 and 50 amperes of current – this requires a #4 or #6 wire. Make sure everything is fused, with a big in-line fuse for the inverter and a fuse block for the 12-volt circuits. Keep in mind that lead-acid batteries are not maintenance free. They need to be kept fully charged and topped up with distilled water. They will periodically also need an equalizing charge that will need to be done with a generator.

Figure 4 — The batteries live in a Rubbermaid-type garden storage box with vents cut in the ends. Lots of other things live there too. Vents are needed because lead-acid batteries produce hydrogen that is extremely corrosive and even more explosive.

All told, our experience is that solar power has worked well at Springwater observatory, but it is expensive and would not be practicable for anything more power hungry than computers and cameras. Don't make it your first choice.

Don van Akker and his wife Elizabeth are members of RASC in Victoria. Don can be reached at dvanakker@gmail.com. He would be glad to discuss solar power or any other Gizmos article if you drop him a line.

Obituaries

Audouin Dollfus (1924-2010)
by R.A. Rosenfeld (randall.rosenfeld@utoronto.ca)

> *One of the things which I discovered...is the importance played by manual dexterity in a successful observation. To observe, it is necessary to make the instruments, to produce them, to adjust them, and to use them with art and finesse. This is never taught.*
> – Audoin Dolfus

On the first of October of this year, the Society lost one of its most distinguished, productive, and inimitable Honorary Members. Audouin Dollfus was a leading planetary scientist whose institutional career was centred almost entirely at the chief French continental observatories, but whose international reputation was established before his 30th year. His important findings spanned

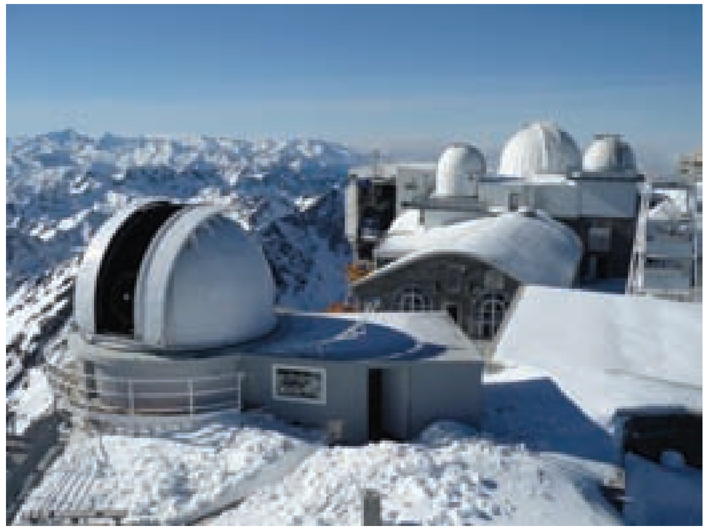


Figure 1 — The observatories at Pic du Midi.

the Solar System, embracing investigations of solar and planetary atmospheric, the characterization and mapping of planetary and satellite surfaces, and studies of the realm of the planetary gas giants and beyond. He was equally known for innovative design work in the field of instrumentation and airborne observatories.

RASC members will chiefly remember Dr. Dollfus for a handful of well-publicized discoveries and endeavours. In 1966, he found the inner Saturnian moon Janus. His ground-breaking polarimetric investigation of the Martian regolith revealed it to be similar in composition to limonite (a medium to dark-brown iron ore), a key pre-*Mariner 9* and *Voyager 1* and *2* finding from the 1950s.

Employing the spectrographically equipped Lyot coronagraph at the Observatoire du Pic du Midi, in the early 1950s he found observational validation of the theoretically predicted 2×10^6 K temperature of the solar corona, a value many in the astrophysics and physics community found stunning and still the subject of vigorous research and debate. This occurred soon after his mentor Bernard Lyot (1897-1952) unexpectedly died in the aftermath of an eclipse expedition, and after the Académie des sciences had devolved the heavy responsibility of continuing and expanding Lyot's programme on the shoulders of the 28-year-old, even before he had obtained his doctorate. Their confidence was not misplaced. NASA in its turn valued his lunar polarimetry and reflectance studies so highly that he was granted ready access to Apollo samples for analysis. The adroitness with which he and his *équipe* (research team) could effectively combine analyses of lab samples with planetary observations was legendary.

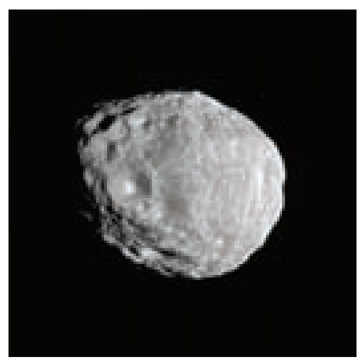


Figure 2 — Saturn's moon Janus. Image: NASA

RASC members, whose recollection reaches back to the twilight of the Chant years, will recall the astronomical world's excitement at the aerostatic astronomy of the intrepid young Dollfus. Over a decade before the first NASA airborne observatories of the mid-1960s, and over two decades before the inaugural flight of the *Kuiper Airborne Observatory* (KAO) in 1977, Dollfus adapted and extended existing balloon technology to carry research equipment into the stratosphere above the interference caused by water vapour. These were hardly unmanned probes; Dollfus, who possessed an aeronaut's licence, braved the stratosphere and ascended himself to operate the telescopes and data collectors. Just as his long association with Henri Camichel (1907-2003) and Lyot provided him with a link to the great visual planetary observers of the late 19th and early 20th centuries, so his father's aeronautical expertise provided him with a link to the earlier world of airborne astronomical observation.

Dollfus' principal observing was done from the Meudon Observatory outside of Paris, using La grande lunette de Meudon (with its 83-cm O.G., the largest refractor in continental Europe) and the 1-m Cassegrain coupled with a long-focus 32-cm O.G. refractor of the Physique du Système solaire laboratory (PSS) – sometimes referred to in jest as his personal telescope. Another favourite was the romantically sited Pic-du-Midi Observatory (3000 m above sea level), where he used the Baillaud telescope, the recycled grand coudé of Paris, the Lyot coronograph, and the 1-m Cassegrain.

Figure 3 — Preparation for a balloon flight to study solar granulation with D.E. Blackwell, D.W. Dewhirst, and Audouin Dollfus at Meudon, Paris. Image: University of Cambridge.

Dollfus was the founding director of the PSS (1960), which proved remarkably productive of results, publications, and students. He also played a key role in the establishment of the IAU's Centre de Photographies planétaires (CPP, 1960-*ca.* 1979) at Meudon. Both the PSS and the CPP undertook research projects for various space agencies. The number of times his earlier findings were confirmed by later space probes is impressive, although he was not always right. He was originally skeptical of the path-breaking work of Charles Boyer, an advanced amateur, and Henri Camichel on the rotation of Venus using UV detection. The important lesson here is that a scientist who is always right is a scientist who timidly lurks in the entourage of others. Dollfus was ever amenable to revising his opinion when presented with better data, better arguments, or solid demonstrations of flaws in his own work. He soon supported Boyer's important findings.

In common with some of his fellow honorary RASC members (*i.e.* Prof. Owen Gingerich of the SAO and Harvard), Dr. Dollfus started as a highly motivated amateur astronomer. He built himself some optically excellent and mechanically ingenious telescopes, experiences he was later to put to professional use. While many professional astronomers are now necessarily involved in instrument design, few of them can carry through the fabrication work with their own hands. Audouin Dollfus was one who could and did.

He became very interested in the history of his discipline, and in the last third of his life, produced many works on the history of astronomy and technology, including the biography of *la grande lunette* itself. More than one notable paper chronicled the history of the Pic du Midi Planetary Observation Project (1941-1971), in particular a component dedicated to the search for life on Mars. Astrobiology remained a life-long interest. Dollfus was also a vigorous popularizer of the discipline, but unfortunately none of his efforts at *haut vulgarization* have yet appeared in English.

He was a great promoter of pro-am collaboration, and was more than willing to give advice and work with any advanced amateur who could function at a professional level. He was also a great believer in international collaboration, which marked his professional work from an early period. Among his collaborators were Gerard Kuiper, Ioannis Focas, Shiro Ebisawa, and Edward Bowell.

One aspect of his work that I found particularly compelling was his use of astrosketching as a scientific technique, in conjunction with data from spectrometers, polarimeters, and photometers. He was a superb planetary draughtsman, and for a long time the Société Astronomique de France (SAF) boutique offered coloured lithographs of his planetary drawings.

He was a member of various planetary and solar commissions of the IAU, the 1974 Harold Jeffreys Lecturer of the Royal Astronomical Society, and the recipient of the SAF's prix Jules Janssen in 1993. In 2009, he was created a chevalier de la Légion d'honneur. In 1980, the asteroid (2451) Dollfus was named in his honour.

Audouin Dollfus remained active to the end, contributing work and maintaining a lively interest in developments in astronomy.

Jack Lambourne Locke (1921-2010)

Figure 1 — Jack Lambourne Locke

Jack Lambourne Locke, former National President (1972-74) and Honorary President (1998-2001) of The Royal Astronomical Society of Canada, died suddenly and peacefully on 2010 April 29 at home in New Westminster, B.C., just two days shy of his 89th birthday. During his distinguished 36-year career in the Federal Public Service as a research scientist and as a scientific director, he witnessed extraordinary growth in astronomical research across Canada and oversaw a major reorganization of government-operated astronomical facilities.

Locke was born on 1921 May 1 and educated in Brantford, Ontario. Recognized as an outstanding student, he was encouraged to pursue a scientific career. He enrolled in the Honours Mathematics, Physics, and Chemistry program at the University of Toronto (UT) in September 1939 at the outbreak of World War II. He continued his undergraduate studies with distinction until May 1942, when he enlisted in the Canadian Navy. For the last two years of the war, Locke was an instructor in submarine detection stationed at HMCS Cornwallis, the Navy's largest training base, next to Nova Scotia's Annapolis Basin. During that posting, he met his future wife, Joyce (Joy) Moxon of Annapolis Royal. On returning to UT, he completed his undergraduate studies with First Class Honours in Physics in 1946 and, upon receiving his B.A., married Joy.

Locke pursued graduate studies at UT's Physics Department under two renowned spectroscopists: Professors Malcolm Crawford and Harry Welsh. His thesis project serendipitously uncovered an entirely new phenomenon: pressure-induced infrared absorption in homonuclear molecules (*e.g.* oxygen, nitrogen, hydrogen). The "Locke Effect," as it became known in Toronto's spectroscopy lab, launched a three-decade-long series of studies by Welsh and his students into spectra induced by intermolecular forces.

On acquiring his doctorate in the spring of 1949, Locke accepted an appointment as Astrophysicist at the Dominion Observatory (DO), then operated by the Department of Mines & Technical Surveys (DMTS) in Ottawa. Its Director, recently appointed in 1946, was giving the four-decades-old institution a much needed shake-up in its astronomical and geophysical divisions. Carlyle S. Beals put Locke in charge of modernizing the DO's solar program. Locke designed an all-mirror high-dispersion grating spectrometer that employed the new generation of infrared detectors emerging from former wartime laboratories. He explored the solar spectrum in the wavelength region of 2.4 microns together with Luise Herzberg. They identified hitherto unreported absorption lines due to the first overtone rotation-vibration bands of carbon monoxide (CO) originating in the solar atmosphere, only to be scooped in publishing the discovery by a team from the University of Michigan. Locke and Herzberg published instead a quantitative study of the variation in the seasonal abundance of CO in the Earth's atmosphere above Ottawa.

Locke's promotion to Chief of the Stellar Physics Division at DO in 1955 led to discussions with Beals regarding long-range plans for the division. Aware of the rapid growth of radio astronomy elsewhere, they envisioned a radio observatory as an essential adjunct to a revitalized DO. Beals saw radio studies of our galaxy as a natural extension of the research into galactic dynamics carried out at the Dominion Astrophysical Observatory (DAO) in Victoria since its inception. Beals quickly obtained approval in 1956 to finance what became the Dominion Radio Astrophysical Observatory (DRAO) on condition that the new observatory be located not far from DAO. Locke and P.E. (Ed) Argyle surveyed southern B.C. for a mountain valley with minimal man-made radio interference. A broad, flat, mountain-rimmed valley at White Lake in B.C.'s Okanagan Valley, just south of Penticton, met all the criteria.

Figure 2 — The DRAO in the 1970s.

The half-dozen years spent in site surveying, planning, building, staffing, and making the first observations at DRAO were undoubtedly the most satisfying and fulfilling years of Locke's astronomical career. He lived in Penticton with Joy and their children during the years 1959-62 while he was the first Officer-in-Charge of the new observatory. He recalls that period with evident relish in a memoir published in this journal (*JRASC 112,* 92, 3).

Locke returned to Ottawa to resume his role as Division Chief in the autumn of 1962. When Beals retired at the end of June 1964, many expected that Locke would succeed him as Director of the Observatories Branch. Instead, DMTS decided it was time for a geophysicist to take charge. So it was that John H. Hodgson, a respected seismologist, was appointed Director. Prior to retiring, Beals had laid the groundwork for establishing a national observatory in which the centrepiece was to be the 3.8-m Queen Elizabeth II Telescope located at the best possible site in Canada. Beals intended that the astronomical units at DO would be transferred to this site, which was selected to be on Mt. Kobau, overlooking the South Okanagan Valley in the B.C. interior. Left with a subordinate role in the development of Mt. Kobau, Locke faced an uncertain future. R.M. Petrie, Director of DAO and the scientist in charge of the QEII Project, was concerned that other telescopes proposed for Mt. Kobau would have a distracting effect on the quick completion of the QEII Telescope. Unwilling to mark time for an undefined number of years until his division's needs were met, Locke resigned from the DO, effective 1966 April 1.

He immediately transferred to the Radio Astronomy Group in the Radio & Electrical Engineering Division (REED) at the National Research Council (NRC), also in Ottawa. Locke joined a team developing a new technique of using wide-band magnetic-tape recorders and transportable atomic frequency standards to operate two widely separated radio telescopes directed at the same point-like source as a phase-coherent interferometer. The revolutionary new idea, occurring independently to several people in the world, was that the separately recorded radio signals could be correlated *a posteriori* with a digital computer, provided sufficiently precise time information was imprinted on each record. The feasibility of the new technique was proven in the spring of 1967 when interferometer "fringes" were detected in records made simultaneously with the 26-m dish at DRAO (Penticton) and NRC's 46-m dish at the Algonquin Radio Observatory (ARO) at Lake Traverse (Ontario), a baseline of 3074 km. The stunning success of the Canadian team, matched weeks later by two American teams using different devices, is recalled in five retrospective articles in the October 1988 (Vol. 82) of the *JRASC*. Long-baseline interferometry made possible the measurement of the diameter of quasars – hitherto unresolved objects of intense radio emission – in the range of 10^{-2} seconds of arc or less.

Locke is among the nine Canadian scientists listed on the Gold Medal of the Rumford Premium awarded the Canadian team in 1971 for their pioneering work in the field of long-baseline interferometry. The two American teams of radio astronomers received separate medals the same year. This prestigious prize, awarded by the American Academy of Arts & Sciences, was established in 1839 to recognize fundamental "contributions in the fields of light and heat, broadly interpreted."

While Canadian radio astronomers triumphed in a new field of endeavour, Canadian optical astronomers were locked in a bitter dispute over the choice of Mt. Kobau for Canada's premiere optical telescope. The furor led to the cancellation of the QEII project by the federal government in August 1968. Consequent to the cancellation, a recommendation was implemented that had been made in 1963 by the Royal Commission on Government Organization: that all governmental astronomy be combined under one agency. A new Astrophysics Branch was set up by NRC on 1970 April 1 to jointly administer DAO, DRAO, ARO, and the Stellar Physics Division of DO. Locke was appointed Chief of the Astrophysics Branch, as well as Associate Director of NRC's REED, which served as the Branch's headquarters.

One of his earliest tasks was to deal with the fallout from the cancellation of the QEII project. A positive outcome was the successful negotiation with a French group seeking a partner to build a similar-sized telescope on Mauna Kea, Hawaii. Although Graham Odgers of DAO spearheaded the initial overtures with the French astronomers, Locke was responsible for shepherding the proposal for a joint Canada-France venture through the various review boards in the federal bureaucracy. Once the Canada-France-Hawaii Telescope (CFHT) was approved, Locke became a member of the Board of Directors of the CFHT Corp. (1974-79), and served as its Chairman in 1976. By all measures, the CFHT, Canada's first international astronomy project, has been a resoundingly successful partnership, in no small measure due to the careful thought Locke and the other founding members invested in crafting the agreement and governance structure.

In 1975, a further reorganization within NRC saw the creation of the Herzberg Institute of Astrophysics (HIA) with Jack Locke as its first Director. At its inception, the HIA combined the Astrophysics Branch with the Spectroscopy and Space Physics Sections of the Division of Physics, and the Upper Atmospheric Research Section of REED. As Director, Locke had to struggle against downward trends in the national economy that constrained the institute's budget and threatened cuts to his staff. The rapid growth of astronomy departments in Canada's universities meant growing demands for access to national facilities operated or supported by HIA (ARO, CFHT, DAO, and DRAO) and for a role in the governance of those facilities. Canadian radio astronomers had divided priorities: to resurface the 46-m dish at ARO for millimetre-wavelength observations or to build an all-Canadian Long-Baseline Array that would provide two-dimensional mapping of quasars at unprecedented spatial resolution. Locke was deeply dismayed by the growing rift in the radio-astronomy community. These pressures so vexed the last few years of his tenure as director that he resigned on 1985 March 22 and retired. He had sacrificed what could have been an outstanding career in radio astronomy in order to secure better facilities for all Canadian astronomers. For assuming this task, and all the risks it entails, the astronomical community in Canada owes Jack Locke a sincere debt of gratitude.

Figure 3 — The Canada-France-Hawaii telescope in 2005.

For his important contributions to Canadian astronomy, Locke was elected a Fellow of the Royal Society of Canada in 1969, and a Member of the Order of Canada in 1997. He was a long-time member of the American Astronomical Society, the Canadian Association of Physicists, the International Astronomical Union, the International Union of Radio Science (Chairman of Commission V (Radio Astronomy) 1972-75), The Royal Astronomical Society of Canada, and in 1971 a Charter Member of CASCA (Canadian Astronomical Society/Société Canadienne d'Astronomie).

Locke's normally genial demeanour masked a highly competitive nature, which was apparent through his keen interest in sports, either as participant or spectator. He was a formidable opponent in any contest, a characteristic that probably did not mellow during his retirement years while he indulged in his favourite games of curling and golf.

Jack Locke was predeceased by his wife Joy in 2004. He is survived by his children, John Andrew (Rosemary) of New Westminster, B.C., and Marion Jane Green (David) of Houston, Texas, and two grandchildren.

This remembrance of Jack Locke was prepared by Victor Gaizauskas with help from Locke's friends and colleagues, Ian Halliday, Jim Hesser, and Lloyd Higgs.

Reviews/Critiques

Copernicus' Secret: How the Scientific Revolution Began, by Jack Repcheck, pages 256, 15 cm × 23 cm, Simon & Schuster, 2007. Price ~$12.00 softcover (ISBN-13: 978-0-7432-8951-1).

Scholars and popular science writers have published many pages over the years about the well-known Nicolaus Copernicus story: the Canon of Frombork's life, his famous treatise of 1543, and its historic impact on Western society's scientific Renaissance. When yet another book appears on the non-fiction bookshelves, now under the enticing title of *Copernicus' Secret*, a cynical reaction could very likely be, "not another Copernican treatment!"

Despite what appears as an obvious 21st-century marketing strategy for a book title (at least to this jaded reader), the audacious use of the word "secret" truly imparts more of a tantalizing aspect to a historical point than what it actually warrants. There was a long delay in the eventual publishing of the Copernican treatise *De revolutionibus orbium coelestium libri sex* [*Six Books on the Revolutions of the Heavenly Spheres*], interpreted as a long-held secret, although not actually so. Owen Gingerich, emeritus professor of astronomy and the history of science at Harvard-Smithsonian Center for Astrophysics, in his 2008 January 13 *New York Times* review of the American edition, wrote that Repcheck "never makes it clear whether Copernicus's [sic] 'secret' is his mistress or his book." That is an excellent point, but given the stature of Copernicus in the history of astronomy, it would be somewhat belittling if the true focus was on his mistress as the big "secret" warranting a reference in the book's title. It was not unheard of for clerics of the day to have mistresses. However, it is *De revolutionibus* that Joachim Rheticus, a friend of Copernicus, ensured was published before Copernicus' death at age 70. The manuscript otherwise may have died with the Canon.

In writing *Copernicus' Secret*, Jack Repcheck has produced a worthy non-fictional account that introduces the novice effectively to the subject, and restates historical information in an engaging and lucid manner for the experienced Copernican. However, there is nothing historically new or revealing in his biography. It happily reads in an upbeat and refreshing manner, focusing on the man and his book.

In the preface, Repcheck notes that he sought to explore "the life of Copernicus, particularly the eventful last twelve years of his life – a dozen years that changed the course of western history." He then concludes the book's preface by stating that his goal has been "to provide a rich, accurate, and especially human account of the events that started a scientific revolution."

On both counts, exploring the life of Copernicus and providing a rich, human account, Repcheck accomplishes the task admirably and succeeds in meeting any lay reader's informational needs. Repcheck touches on all the appropriate biographical elements of Copernicus' life at a very general level, without getting bogged down in superficial minutiae or delving into heavy, scholarly analyses or scientific discussions about Copernicus' new Solar System model. The book is a story of Copernicus, the human being, and the people around him who were involved in the eventual publishing of the Canon of Frombork's thundering opus: the determining achievement of his life's scientific work.

Copernicus' Secret contains 18 chapters with such titles as Childhood, Student Years, The Mistress and the Frombork Wenches, Convincing Copernicus, The Publication, The Death of Copernicus, Rheticus after Copernicus, and The Impact of *On the Revolutions*. The chapters on the convincing of Copernicus to publish his decades-in-the-making manuscript, the actual publication of the book itself, his death, and the book's impact are very well crafted, flowing logically and informatively. They make an enjoyable read.

Although *Copernicus' Secret* is crafted as a popular book, the author does not resist in touching on some scandalous tidbits of the time. There are references to Copernicus' mistress and the pressure exerted by his Bishop to drop her. And then, there is a brief mention of an event in the life of Georg Joachim Rheticus, who in April 1551 was accused of homosexual rape. As a young man, Rheticus tracked down Copernicus, then in his late 60s, and revitalized the aging cleric's spirits, staying with him on-and-off for some two years, until the *De revolutionibus* manuscript was finished. Rheticus then brought the manuscript to a printing press for publication.

Copernicus' Secret: How the Scientific Revolution Began includes a convenient listing of "Selected Sources": primary, biographical, and important secondary sources. The author has also provided a short section of "Suggested Additional Readings" with explanatory guidance. That is most useful. In summary, *Copernicus' Secret* is a welcome addition to anyone's personal library on matters related to historical astronomy and the life and impact of Copernicus.

Andrew I. Oakes

Andrew I. Oakes is a long-time member of the RASC, an armchair amateur astronomer who collects books on Copernicus. He lives in Courtice, Ontario.

Small Telescopes and Astronomical Research, edited by Russell M. Genet, Jolyon M. Johnson, and Vera Wallen, foreword by Alex Filippenko, pages 332i, 15 cm × 23 cm, Collins Foundation Press, 2009. Price $29.95 US paperback (ISBN: 978-0-9788441-3-4).

Individuals in communities throughout the world are employing modest-sized telescopes to make pertinent contributions to our knowledge of the universe. *Small Telescopes and Astronomical Research* describes that culture and provides a basis for those interested in tackling astronomical research projects and joining organizations that may facilitate the process (where personal partnerships may be formed). Indeed, B.Sc., M.Sc., or Ph.D. degrees in astronomy are not pre-requisites for participating in exciting science. The book and references therein describe how non-professionals can, for example, establish the geometric morphologies of asteroids through observations of occultations, participate in the search for life by detecting and monitoring exoplanets, discover supernovae in distant galaxies that could inevitably be used to establish the distance scale and cosmological nature of the Universe, constrain the parameters of binary systems, which constitute a sizeable fraction of the stellar demographic, and use small observatories to provide hands-on training for the next generation of young scientists.

Perhaps the most admirable aspect of *Small Telescopes and Astronomical Research* is the underlying philosophy that reverberates throughout, namely the unyielding devotion that amateur astronomers exhibit toward educating youth, each other, and society at large. Russ Genet, one of the authors, supports a young individual named Joylon Johnson, whose miraculous transformation is described in Joylon's own words: "In the two years since I met Russ, I accomplished more than in the previous 19 years of my life. I went from cashier at a fast food restaurant to science advisor of the Orion Observatory, from causal Internet article browser to editor of astronomy books. I can hardly imagine what adventures of cosmic discovery the next two years will bring as I continue my science education." Russ reinforces the importance of partnership between science and society in his young pupil, adding that moral compass. He is an encourager, not an obstructionist. As Joylon Johnson continues his path as an astronomer, he will propagate that attitude *X* times to *X* youth. Consider what might have happened if Canadian astronomer Wendy Freedman – the principal investigator of the HST's key project to measure the expansion of the Universe, and the recipient of the prestigious Gruber Foundation cosmology prize – was instructed by a 10th grade teacher to tune out when the technical aspects of physics were discussed. How many potential Wendy Freedman's have we lost at the behest of such obstructionists? The losses will (hopefully) be mitigated with folks like Johnson and Genet propagating the aforementioned demeanour, and the latter should be lauded for such efforts.

The breadth of the Universe results in an equally vast number of topics that can and should be studied. Every new and old participant should therefore be heralded and supported, especially since a society with intimate knowledge of the cosmos is less likely to highlight artificial differences between its constituents and engage in unnecessary conflict. Let organizations like the RASC, IOTA, and the AAVSO flourish and continue the promotion of astronomical education throughout society. *Small Telescopes and Astronomical Research* exemplifies that movement and attitude, while providing examples of interesting projects folks are undertaking that should instill ample motivation for the reader. Over 30 years ago, Canadian astronomer Dr. John Percy rightly predicted that "There will always be a place at the forefront of astronomical research for yet another small telescope – amateur or professional – carefully and imaginatively used."

Daniel J. Majaess

Daniel Majaess is conducting his apprenticeship in astronomy research under the supervision of former JRASC *editor David Turner and the RASC's Past President Dave Lane. He regularly uses small telescopes for his research.*

Light-Pollution Abatement Committee (LPAC)

by Robert Dick, Chair, LPAC (Robert_Dick@carleton.ca)

I would like to announce and introduce the members of the Light-Pollution Abatement Committee.

The LPAC manages the Dark-Sky Preserve Program and promotes the reduction of light pollution across Canada. The RASC benefits from their work with the preservation of observing sites and the reduction of light pollution in our communities that comes from raising the public's awareness of light as a pollutant.

Committee members perform literature research, develop presentations, and deliver talks on the subjects of their work. They take initiatives by approaching local governments and business with the goal of reducing light pollution across Canada. The LPA Committee is very much a "doing" Committee with their attention focused outside the RASC.

The LPAC was recently re-formed with two new members: Brian Lucas and Dorothy Paul. Our Committee membership is spread across the country, so there should be a member in "your neck of the woods," if you need help or have some initiatives you would like to discuss.

You don't have to be on the Committee to work on reducing LP in your community and our Committee can help you get started. You can also join the LPA discussion list that is open to all RASC members. You can join the LPA Discussion Group with a request from the LPA page (see right menu) on the National RASC Web page (`www.rasc.ca/committees/lpa.shtml`).

In alphabetical order, the eight LPA Committee members are:

Mark Coady	Bellville Centre	lightpollutionabatement@gmail.com
Roland Dechesne	Calgary Centre	Roland.Dechesne@cnrl.com
Robert Dick (Chair)	Ottawa Centre	rdick@robertdick.ca
Yvan Dutil	Quebec Centre	Yvan.Dutil@sympatico.ca
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Dan Taylor	Windsor Centre	dctaylor@xplornet.com
Chris Weadick	New Brunswick Centre	chris.weadick@gmail.com
Mary Lou Whitehorne	Halifax Centre	mlwhitehorne@hfx.eastlink.ca

Stars over the Bruce Peninsula DSP (Image: R. Dick - representative composite)

Society News

by James Edgar, Regina Centre (jamesedgar@sasktel.net)

For the third year running, the Executive Committee met at a weekend retreat to develop plans, goals, and strategy. (Sounds exciting, doesn't it?) This year is different in several ways: the previous meetings were in Halifax (seemed right with two Executive members living there) – this year, we met in Toronto (with three members living there); this is our first chance to work together with RASC President Mary Lou Whitehorne leading us; and, with two new Executive members on board, Colin Haig and Deborah Thompson, we will see the group dynamics changed considerably from previous years.

We haven't actually met yet, as I'm writing this the week before we meet, but I can tell you that Deborah Thompson, our new Executive Director, has plenty of work lined up for us. In fact, we've been hard at it for the past month or more already, developing a SWOT* analysis and striving for a long-range plan that will take us forward into the future. (See page 260 for our newly developed Mission, Vision, and Values statements.)

Our Public Speaker Programme is well on its way, with the first grants going to sponsor speakers at the Halifax Centre on September 17; Toronto Centre on October 16; and the London, Hamilton, Windsor, and Sarnia Centres on November 16-19. Congratulations to these applicants. We have feelers already out from the Prince George Centre for a speaker in early 2011, so Centre executives, get your thinking caps on, and let's make this programme really fly! Wouldn't it be great if we had to turn down applications because there were too many?

*SWOT = Strengths, Weaknesses, Opportunities, Threats

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With this issue, we say goodbye and "Thank you" to Guy Nason, who is "retiring" as a regular *Journal* author. Guy's amusing stories on his expeditions to determine the size of asteroids by their occultation of a star, and his explanations on how it's done, have been a popular column in the *JRASC* for the past five years. We can only hope that others have been inspired to join the star-blink community as a result. Guy will continue to write occasional articles about his adventures.

The Royal Astronomical Society of Canada

Mission

The Royal Astronomical Society of Canada (RASC) encourages improved understanding of astronomy for all, through education, outreach, research, publication, partnership, and community. Founded in 1868, the RASC is Canada's leading astronomy organization, with 29 Centres across the country and over 4000 members.

Vision

To inspire curiosity in all Canadians about the Universe. To share scientific knowledge and to foster collaboration in astronomical pursuits.

Values

The RASC has a proud heritage of excellence and integrity in its programmes and partnerships. As a vital part of Canada's science community, we support discovery through the scientific method. We inspire and encourage people of all ages to learn about and enjoy astronomy.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

NATIONAL OFFICERS AND COUNCIL FOR 2010–2011/CONSEIL ET ADMINISTRATEURS NATIONAUX

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Great Images

Winnipeg is in the main flyway for migrating Canada geese, and Mark Burnell was in the right spot – at Oak Hammock Marsh, north of the city – to capture this low-flying group silhouetted against the crescent Moon. In Mark's words "As I was doing this [photographing the Moon] I noticed with my other eye (sports photography: always keep both eyes open) some birds flying towards my field of view. Sure enough, they flew right in front of the Moon." Exposure 1/30th second at f/2.8 and ISO 2000, using a Canon 50D and a zoom lens set at 200 mm.